Vol. 27 January, 1934 No. 3

# QUARTERLY

OF THE

# National Fire Protection Association

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60 BATTERYMARCH STREET, BOSTON, MASS.

# National Fire Protection Association

INTERNATIONAL

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*Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.*

*Acme Photo.*

**Pier fires present a difficult problem in fire fighting even when the fire does not extend under the pier deck. This photograph shows the burning of Central Wharf, Boston, on Nov. 7, 1933. Inferior construction, absence of automatic fire alarm or sprinkler protection, large areas without fire breaks, highly combustible contents, and a delayed alarm gave the fire opportunity to gain headway before the arrival of the fire department. Prompt action in massing heavy streams from three fireboats and land apparatus prevented a more serious fire. The hazards of this pier were cited by N.F.P.A. field engineers in 1929 as typical of waterfront property to which the city building code does not apply.**

# The Quarterly

Vol. 27 January, 1934 No. 3

**The 1933 Fire Loss.** The U. S. fire loss estimates for 1933 reported on another page of this QUARTERLY show a decrease of some $120,000,000 as compared with the similar estimate for 1932, a decline of more than 25%. Various authorities attribute this material reduction in the national fire losses to different causes. It is noteworthy, however, that the initial drop was coincident with the declaration of the bank moratorium and the adoption of the 60-day rule by the insurance companies. The effect of the bank moratorium was to create skepticism as to the solvency of all financial institutions, insurance companies as well as banks, and made it temporarily impossible for the companies to pay losses. The decision to withhold payment of losses for 60 days discouraged incendiarism and made honest property owners unusually careful to avoid having fires.

Other factors in the lower loss for 1933 may be the better co-ordination of fire prevention activities, more favorable weather conditions, the upturn in business since March and the general drive against arson, resulting in a higher percentage of arson convictions. This drive came opportunely, at a time when the rising tide of incendiarism had reached the dwelling house, a classification normally least affected by arson. Just what per cent of the fire loss of the country is due to arson is a matter of conjecture, but the experience of the past year seems to substantiate the opinion that incendiarism, deliberate or unconscious, is responsible for a very substantial part of the total fire loss.

* * * * * *

**Fire Prevention Week Results.** Mr. T. Alfred Fleming, chairman of the N.F.P.A. Committee on Fire Prevention and Clean Up Campaigns, compiling the results of the 1933 Fire Prevention Week Campaign, finds a large increase in the number of cities reporting Fire Prevention Week observances and a further improvement in the effectiveness of the campaign. The reports have been reviewed by a committee of judges, and citations of merit made for the leading cities in each State and Province.

Of the cities reporting in the United States, 76 suffered no loss by fire during the week of October 1st to 7th, 92 escaped damage from burning during Fire Prevention Week, October 8th to 14th, and 81 reported no fire loss throughout the following week. This is a total of 249 fireless weeks covered by the period of this special fire prevention observance. Eighty-one cities showed a weekly loss of less than $25.00. The fire loss in the cities submitting such records, as compared with the average weekly loss of the same cities for the previous year, showed a reduction of 67 per cent.

The report from Canada shows increased interest by the public in this important patriotic work. During the last two years, with less funds available, efforts have been largely of individual initiative. In the Provinces special attention was given to the inspection of buildings which had become dilapidated because of economic conditions. A creditable result is shown in the reduction of losses from this type of property.

The results of Fire Prevention Week, recorded year after year, prove beyond question the value of the observance, both in immediate results and in stimulation of fire prevention activity throughout the year.

* * * * * *

**Tank Truck Regulation.** The record of tank truck fires printed in this QUARTERLY directs attention to the valuable work of the N.F.P.A. Committee on Flammable Liquids in this field. This committee, early recognizing a potential hazard in the transportation of flammable liquids by improperly constructed and carelessly operated tank vehicles, first submitted a preliminary report on the subject in 1926. Immediately thereafter the committee, with the coöperation of the American Petroleum Institute (member N.F.P.A.) and tank-truck manufacturers generally, undertook the preparation of a Recommended Good Practice for the Construction and Operation of Automobile Gasoline Tank Trucks. This report, which specifies reasonable provisions for safeguarding the public interest without working undue hardship on industry, was adopted and published by the Association in 1929. Subsequently, to meet a demand for a report in suggested ordinance form, covering not only gasoline tank trucks but trucks for other flammable liquids, a suggested ordinance on this subject was adopted by the Association at the 1933 annual meeting. The provisions contained in the suggested ordinance are generally recognized and usually applied as minimum requirements by both makers and users of tank trucks designed for the transportation of flammable liquids. One eastern state has adopted the N.F.P.A. recommended good practice as its regulations with the force of law, and preliminary steps have been taken for similar adoption in at least one other state.

The highway transportation of flammable liquids inevitably involves some degree of fire hazard. Public convenience and necessity require such

transportation on a large scale. These facts are both given due consideration in the Association's Suggested Ordinance. The large oil companies fully appreciate the importance of fire-prevention precautions, but smaller operators in many cases do not give sufficient consideration to such precautions. Regulation by state or city authority seems to be the practical way to control the irresponsible operator and to remove from the larger companies the temptation to relax precautions in order to meet the competition of concerns that distribute flammable liquids without regard to public safety. N.F.P.A. members can render a major service in bringing their influence to bear on public authorities for the adoption of the N.F.P.A. Suggested Ordinance Regulating the Construction and Operation of Automobile Tank Trucks and Tank Trailers.

* * * * * *

**Porto Rico Film Fire.** In an isolated shack in Caguas, Porto Rico, on Sunday, November 17, twelve children and four adults were watching a motion picture entertainment held in a room 11 x 17 ft. in size. Several reels of nitrocellulose motion picture film without metal containers were kept in an open barrel. A lighted candle fell into the barrel. . . . Eleven lives were lost, nine children and two adults.

This fire is a grim reminder of the ever present hazard of nitrocellulose film. The good record of motion picture film storage and handling in the Continental United States and in Canada for the past several years, due largely to the efforts of the Motion Picture Producers and Distributors of America (member N.F.P.A.) and the similar Canadian organization, should not be allowed to lead to any relaxation of precautions in respect to this inherently dangerous material. Nitrocellulose film should be strictly confined to professional use, where it will be handled only by those familiar with its properties and where the safeguards recommended by the N.F.P.A. Committee on Hazardous Chemicals and Explosives will be observed.

* * * * * *

**Self-Extinguishing Fires.** From time to time reports are received of small fires in confined spaces which have apparently burned themselves out for lack of air. Theoretically any fire in a tight enclosure will go out as soon as it has exhausted the available air supply, but as a practical matter few enclosures are sufficiently tight to bring about this result. Speaking before the Northwest Fire School at Minneapolis last summer District Chief Leslie Shewan of the Winnipeg Fire Department referred to three fires in Winnipeg during the preceding year that extinguished themselves in this way. One of these, cited as typical, occurred in a chain store. When the manager opened the store in the morning he found the building filled with stagnant smoke. Fire had started in the basement, apparently burning vigor-

ously for a time. All the stock in the store was ruined. The building was tight and well constructed, and the fire had gone out from lack of oxygen.

What is probably the most extensive fire in this class that has been recorded to date is one reported by Fire Chief George F. Graff of New Albany, Indiana, on July 28, 1933. The occupants of a house on Silver Hills near New Albany were away in Chicago for a week and the house was closed. No one knew there was a fire until the family returned to find all the rooms on the first floor completely burned out and upstairs everything black from smoke. Chief Graff investigated and found evidence of considerable fire. The furnishings and stairs were burned; electric light bulbs had melted. Glass in the windows had softened from the heat. The outside of the building showed no signs of fire and a neighbor living within fifty feet had not noticed any fire nor smelled smoke. The chief is of the opinion that the fire burned out of its own accord.

It is a well-known fact that the products of combustion of a fire constitute an excellent fire extinguishing agent if properly applied, but in present practice it is seldom possible to extinguish a fire by cutting off all ventilation. If the conditions under which fire would be self-extinguishing could be determined and reproduced in practice we might have a very interesting new development in fire extinguishing technique.

* * * * * *

**The Index.** Printed as Part 2 of this QUARTERLY is a general index of N.F.P.A. publications from September, 1926 to January, 1934 (not including this QUARTERLY). This 48-page listing of subjects treated in N.F.P.A. publications during the past seven years furnishes concrete evidence of the wide ramification of fire prevention and fire protection, and of the comprehensive character of N.F.P.A. literature. Only the main headings considered necessary to identify and locate the material indexed have been included. Subsidiary items, if indexed, would increase the list to several times its present size.

# The 1933 U. S. Fire Loss.

The preliminary estimate of the fire loss in the United States for the year 1933 is $318,200,000. This amount is based on estimates compiled by the National Board of Fire Underwriters for the eleven months ended November 30, 1933, with a figure for December based upon loss experience for the same month in previous years adjusted for the loss trend of the current year. The total estimate is approximately 120 million dollars less than the 1932 preliminary loss estimate, a reduction of 27.7 per cent, and the lowest annual aggregate loss recorded in fourteen years.

## Comparative Monthly Loss Estimates, 1931, 1932, and 1933.

| | 1931 | 1932 | 1933 |
|---|---|---|---|
| January | $44,090,449 | $39,224,783 | $35,547,565 |
| February | 41,776,051 | 39,824,622 | 36,661,481 |
| March | 44,074,362 | 49,189,124 | 35,321,248 |
| April | 41,423,764 | 43,822,233 | 27,825,970 |
| May | 37,835,273 | 39,270,524 | 24,338,714 |
| June | 33,368,378 | 34,338,670 | 21,578,609 |
| July | 33,024,594 | 32,982,434 | 20,004,049 |
| August | 31,917,630 | 31,425,931 | 23,626,505 |
| September | 33,202,986 | 30,972,318 | 20,447,571 |
| October | 35,501,530 | 30,734,458 | 21,465,382 |
| November | 35,287,641 | 31,167,708 | 22,454,200 |
| Total 11 months... | $411,502,658 | $402,952,805 | $289,271,294 |
| December | 40,514,368 | 39,190,506 | 29,000,000* |
| Total 12 months... | $452,017,026 | $442,143,311 | $318,271,294 |
| Adjusted loss figures.. (Released later in year.) | $451,643,866 | $406,885,959 | |

## Aggregate Loss for Eighteen Years Approximates Eight Billion Dollars.

The 1933 fire loss brings the total fire waste of the United States during the past eighteen years up to the stupendous sum of $7,988,452,556, an annual average of approximately 440 million dollars. The following table gives the annual fire losses by years since 1916.

| | | | |
|---|---|---|---|
| 1916 | $258,377,952 | 1925 | $559,418,184 |
| 1917 | 289,535,050 | 1926 | 561,980,751 |
| 1918 | 353,878,876 | 1927 | 472,933,969 |
| 1919 | 320,540,399 | 1928 | 464,607,102 |
| 1920 | 447,886,677 | 1929 | 459,445,778 |
| 1921 | 495,406,012 | 1930 | 501,980,624 |
| 1922 | 506,541,001 | 1931 | 451,643,866 |
| 1923 | 535,372,782 | 1932 | 406,885,959† |
| 1924 | 549,062,124 | 1933 (Est.) | 318,271,294 |
| | | Total | $7,941,396,301 |

*December figure is taken as an average of the losses for the previous years adjusted for the 1933 trend.

†A final adjusted figure for 1932 will be published in the April 1934 QUARTERLY.

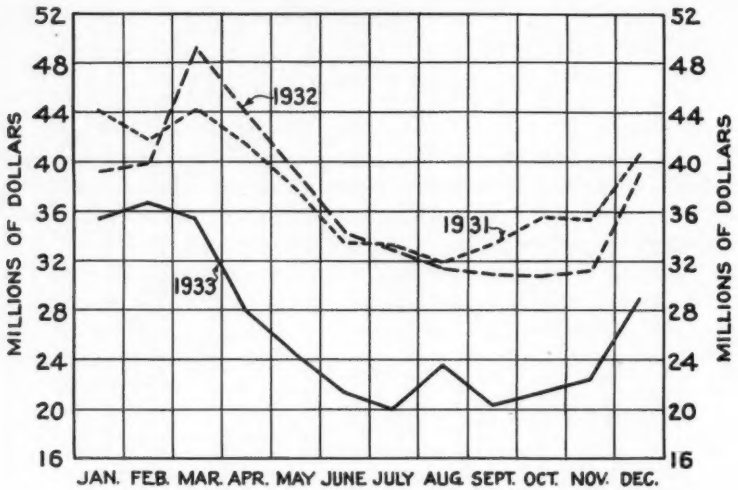


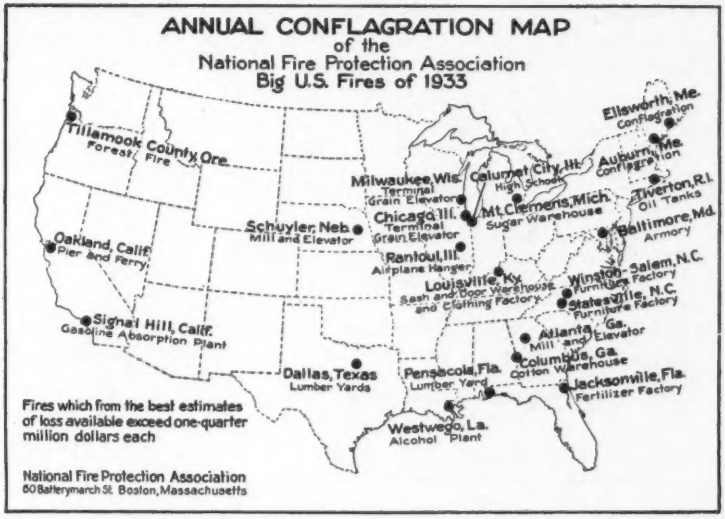

Chart of U. S. fire losses by months.

## Large Loss Fires in U. S., 1933.

During the year 1933 there were reported to the N.F.P.A. Department of Fire Record twenty-two fires involving a loss estimated at $250,000 or over, a decrease of twenty-two over the previous year. This decrease may be accounted for in part by the general economic conditions which have been responsible for the reduction in the total national loss for the same period. In addition to these factors, the reduction in burnable material in mercantile and manufacturing occupancies, both in units and dollar value, has undoubtedly been a factor in the lesser number of fires in which the loss has reached the quarter million dollar mark.

Three of the large loss fires of 1933 have, by reason of their extent and loss, been classified as conflagrations. The first of these occurred on the night of May 7 at Ellsworth, Maine, and wiped out a portion of the business district and approximately a third of the residential section. Most of the structures involved were of wooden construction and of 127 buildings totally destroyed, 94 were listed as having wooden shingle roofs. The total loss was estimated at approximately $1,350,000. A detailed account of this fire was published in the QUARTERLY, July, 1933 (Vol. 27, No. 1, Page 44.)

The second fire of conflagration proportions was that which swept another Maine community, Auburn, on May 15, a week and a day after the Ellsworth disaster. This resulted in the destruction of 250 buildings in a congested business and residential section where frame construction predominated. Wooden shingle roofs, delayed response of the fire department,


ANNUAL CONFLAGRATION MAP
of the
National Fire Protection Association
Big U.S. Fires of 1933
Tillamook County, Ore. Forest Fire
Oakland, Calif. Pier and Ferry
Signal Hill, Calif. Gasoline Absorption Plant
Schuyler, Neb. Mill and Elevator
Milwaukee, Wis. Terminal Grain Elevator
Chicago, Ill. Terminal Grain Elevator
Rantoul, Ill. Airplane Hangar
Calumet City, Ill. High School
Louisville, Ky. Sash and Door Warehouse and Clothing Factory
Mt. Clemens, Mich. Sugar Warehouse
Ellsworth, Me. Conflagration
Auburn, Me. Conflagration
Tiverton, R.I. Oil Tanks
Baltimore, Md. Armory
Winston-Salem, N.C. Furniture Factory
Statesville, N.C. Furniture Factory
Atlanta, Ga. Mill and Elevator
Columbus, Ga. Cotton Warehouse
Jacksonville, Fla. Fertilizer Factory
Dallas, Texas Lumber Yards
Pensacola, Fla. Lumber Yard
Westwego, La. Alcohol Plant
Fires which from the best estimates of loss available exceed one-quarter million dollars each
National Fire Protection Association
60 Batterymarch St. Boston, Massachusetts

and limited water supplies, combined with weather favorable to the spread of the fire, created conditions which facilitated the rapid development of the original blaze into a fire of conflagration proportions. The loss was estimated at $1,500,000. A detailed account of this fire was published in the QUARTERLY, July, 1933 (Vol. 27, No. 1, Page 59).

The third conflagration occurred from August 14 to 26 inclusive in Tillamook County, Oregon. Approximately 300,000 acres of forest area were burned over and it is estimated that ten billion feet of high grade virgin timber was destroyed. The direct property loss to the owners of the timber is estimated between $10,000,000 and $20,000,000 based on present discounted values. Indirect losses, including taxes, labor and freight charges, which would have normally benefited had the timber been liquidated in a normal way during the next fifteen or twenty years, will amount to many times the direct fire loss. A story of this fire appears on page 198 of this QUARTERLY.

There were seven fires involving single buildings and adjacent property where the reported loss was $500,000 or more. A tabulation of these fires follows:

| | |
|---|---|
| February 9, 1933, Chicago, Ill., Terminal Grain Elevator... | $830,000 |
| May 6, 1933, Oakland, Cal., Pier and Ferry..... | 1,143,000 |
| June 2, 1933, Signal Hill, Cal., Gasoline Absorption Plant.. | 500,000 |
| August 15, 1933, Milwaukee, Wis., Terminal Grain Elevator | 606,000 |
| October 9, 1933, Pensacola, Fla., Lumber Yard..... | 599,000 |
| November 1, 1933, Tiverton, R. I., Bulk Petroleum Storage | 700,000 |
| December 13, 1933, Mt. Clemens, Mich., Sugar Warehouse | 500,000 |

In 1933 the variety of occupancies involved made it difficult to follow the method of classification used in previous years and but three classifications have been used. It will be readily noted that the number of fires classified as "miscellaneous" is far below the record for previous years. The total estimated loss in these fires for 1933 was $20,872,000. Exclusive of the Oregon forest conflagration the loss was $10,872,000, an average of $518,000 per fire, as compared with an average of $454,000 per fire in 1932.

| Occupancy | No. of Fires | Estimated Loss |
|---|---|---|
| **Mercantile or Manufacturing Occupancies** | | |
| Terminal grain elevators | 2 | $1,436,000 |
| Mill and elevator | 2 | 766,000 |
| Furniture factories | 2 | 700,000 |
| Lumber yards | 2 | 869,000 |
| Cotton warehouse | 1 | 418,000 |
| Gasoline absorption plant | 1 | 500,000 |
| Alcohol refinery | 1 | 360,000 |
| Warehouse and clothing factory | 1 | 250,000 |
| Bulk petroleum storage | 1 | 700,000* |
| Fertilizer factory | 1 | 250,000* |
| Sugar warehouse | 1 | 500,000* |
| **Miscellaneous Occupancies** | | |
| Armory | 1 | 460,000 |
| Pier and ferry | 1 | 1,143,000 |
| Airplane hangar | 1 | 250,000* |
| School | 1 | 420,000* |
| **Conflagrations** | | |
| City | 2 | 1,850,000 |
| Forest | 1 | 10,000,000* |
| Total | 22 | $20,872,000 |

With three exceptions, these fires occurred within the jurisdiction of municipal fire departments. The following table indicates in a general way how they were handled.

| | No. of Fires |
|---|---|
| City fire department alone | 12 |
| City fire department and outside aid | 6 |
| Outside fire departments | 5 |
| City fire department and private fire brigade | 1 |
| City fire department, outside aid, and private brigade | 1 |
| Forest fire fighting equipment | 1 |
| Total | 22 |

In order to determine the factors that have been responsible for making these twenty-one fires large loss fires, an analysis has been made of the reports of these fires which have been filed with the N.F.P.A. Department of Fire Record. Not all large losses can be attributed to a single factor, and in some instances a number of factors have been equally responsible for the rapid

*Authentic loss figures based on final adjustments have not yet been received for these fires. The figures used in the record have, however, been subjected to careful check and are believed to be substantially correct.

spread of, and consequent large damage by, the fire. The fire which swept the business and residential section of Ellsworth, Maine is a typical example. It is reported that the reasons for this large loss were (1) the predominance of wooden shingle roofs; (2) headway of fire when fire department arrived; (3)unfavorable weather conditions; (4) inferior construction; and (5) limited water supplies.

**Reasons for Large Loss.**

| | No. of Fires |
|---|---|
| Inferior construction | 14 |
| Headway of fire when discovered | 11 |
| Ineffective fire fighting | 8 |
| Failure of private fire protection — 3 | |
| Inefficient fire fighting (including bursting of hose) — 3 | |
| Fire department delayed in getting to work — 2 | |
| Unfavorable weather conditions | 9 |
| Highly combustible contents or excessive amounts of burnable materials | 7 |
| Lack of adequate public or private protection | 5 |
| Sprinkler equipment shut off | 4 |
| Inadequate water supplies | 4 |
| Point of origin difficult of access | 3 |
| Large quantities of flammable liquids | 3 |
| Delayed alarm | 3 |
| Explosions aided rapid spread of fire | 2 |
| Wooden shingle roofs | 2 |
| Delayed fire department response | 2 |
| Lack of exposure protection | 1 |
| Contents especially susceptible to water damage | 1 |
| Forest inaccessible and in tinder-like condition | 1 |

As in 1932 "inferior construction" was the factor most frequently noted as responsible for large loss fires in 1933. Typical fires where inferior construction played a major part were the Statesville Furniture Co. fire in Statesville, N. C., on February 24, the two State of Maine conflagrations at Ellsworth and Auburn in May, and the mill and elevator fire at Schuyler, Nebraska, in October.

The headway of the fire when discovered was also a principal factor in approximately half of the fires reported. It is interesting to note that of the ten fires in which this was reported as a principal factor seven occurred between 8 P.M. and 8 A.M., one occurred on a Saturday afternoon when the building was normally closed, and one occurred in idle property.

Ineffective fire fighting and unfavorable weather conditions have played a greater part in the large loss fires of 1933 than in the large loss fires of the last two previous years. Under the latter heading have been included such factors as extreme cold, high winds, low humidity, etc., which obviously facilitate the rapid spread of fire once it has gained headway.

Another important factor was "highly combustible contents or excessive amounts of burnable materials." This is to be expected, for when large stocks of readily combustible and free burning materials are once well involved, a large loss is inevitable. Characteristic fires of this sort were the lumber yard fires in Dallas, Tex., and Pensacola, Florida, resulting in the aggregate destruction of more than $800,000 worth of lumber and buildings.

### Large Loss Fires in Canada.

Reports of six Canadian fires involving individual losses of $250,000 or over have been received by the N.F.P.A. Department of Fire Record. These caused an aggregate loss estimated at $2,944,000, almost two-thirds of which was chargeable to four fires in church, and parochial school or college property. A summary of the large fires is as follows:

| | |
|---|---|
| January 12, 1933, Montreal, P. Q., St. Louis de France Church | $409,800 |
| March 26, 1933, Montreal, P. Q., St. Jacques le Mineur Church | 650,000 |
| August 29, 1933, Spragge, Ont., Lumber Mill and Yard | 525,000 |
| September 19, 1933, Halifax, N. S., Pier and Warehouse | 402,000 |
| September 22, 1933, Valleyfield, P. Q., Church and Convent | 512,200 |
| October 20, 1933, St. Joseph, N. B., College | 445,000 |
| Total | $2,944,000 |

## Los Angeles Brush Fire Disaster.

By Chief Ralph J. Scott,
(Member N.F.P.A.).

Twenty-eight men, workers on a county unemployment relief project, lost their lives when a brush fire which they were fighting swept upward through a canyon in the suburbs of Los Angeles, California, on the afternoon of October 3, 1933. How many others were treated for burns is not definitely known, but 104 cases were treated at the Receiving Hospital and its branches, and fire department members rendered first aid treatment to more than 50 persons.

The fire occurred in a division of the Los Angeles park system known as Griffith Park. A paved highway encircles the golf links in the park and passes the mouths of Dam Canyon and Mineral Wells Canyon at the foot of the hills forming the north slope of the Santa Monica mountains. From the highway the hill rises rapidly at a grade approximating 35 per cent to a ridge or divide, which continues irregularly in a southerly direction.

The fire started from causes not definitely determined, but surmised to be the discarded cigarette or match of a careless smoker, about 50 feet south of the highway and approximately midway between the two canyons. There are no precipitous grades in the area involved in the fire, the slopes ranging from about 20 per cent to a maximum of about 50 per cent. This very fact,

**Looking southwest into Dam Canyon, showing origin and extent of fire and where twenty-eight men were trapped and burned to death.**

however, and the fact that the area all lies on the north side of the range, makes conditions favorable for an unusually thick growth of brush and scrub trees, furnishing an abundance of fuel for a fire once started. A narrow road leads from the mouth of Dam Canyon to the Girls' Recreation Camp, a project of the City Playground and Recreation Department. This road is not suitable for automobiles or fire apparatus and is not intended for the use of such vehicles. There were no fire-breaks which might be utilized in stopping the fire, although the territory was crossed with narrow trails known as "deer trails" which, while passable and rendering all of the area accessible, were of small value to facilitate the escape of men who were panic-stricken with fear and excitement.

### Weather Conditions.

The afternoon of October 3 was very hot, an unofficial report indicating 110° F. at noon, near the scene of the fire. The relative humidity was unusually low, much lower than the average summer humidity for this territory. These factors contributed materially to the loss of life in this fire. The excessive heat made operations of fire-break cutting difficult and laborious. Men became exhausted quickly and required frequent rest periods to permit them to continue activity. It is reasonable, therefore, to believe that had it not been for the unfavorable weather conditions, combined with the heat of the fire itself, many more men would have been able to save themselves from death in the flames.

### Story of the Fire.

The first notification of the fire was received by the Los Angeles fire alarm office at 2:26 P.M., when the operator of the Glendale Fire Department telephoned that a report had been received of a fire in Griffith Park. At about the same time a similar call was received from the foreman of the Griffith Park clubhouse, giving the exact location of the fire. Engine Co. 56, Hose Co. 27, and a battalion chief were immediately dispatched to the fire, the chief and the engine company arriving in something less than ten minutes at the point where the fire started. The hose company entered the park from another direction, arriving at a point on the high road immediately above and to the west of the main fire area.

On the arrival of the battalion chief, a call was transmitted for 40 additional men, which request was received at 2:36 P.M and was answered by the crew of the Mountain Patrol and 16 men detailed from the drill school. Additional calls were later transmitted for ambulances, rescue companies, tank wagon, light wagon, and men for relief to patrol the area to guard against rekindling after the fire was out. When the battalion chief first reached the fire (2:36 P.M), it had involved practically all the area between Dam Canyon and Mineral Wells Canyon on the lower slopes and had advanced up the hill to the point where the grade of the ridge flattens out.

The first company to arrive at the fire (Engine Co. 56) went to work with their booster tank and chemical hose at a point near the entrance to Dam Canyon, which could be reached with the limited hose and water facilities available. At the same time a group of men with 1½-inch hose were sent up the canyon to the Girls' Recreation Camp in order to prevent the spread of the fire in that direction. This was the only point at which any water was available and it is important to note that even this restricted water supply, which was sufficient only to supply one 1½-inch line, was of inestimable value in stopping the fire at this point. The hose company responding to the first alarm reached a point about a half mile west of the fire at 2:40 P.M., and equipped with shovels and canteens the men proceeded out on the ridge dividing the canyons. A crew of approximately 500 laborers was stationed along the trail leading to the fire and with their assistance the officer in charge of the hose company brought the fire under control at this point.

The first evidence of casualties was received about 3:15 P.M., when the assistant chief, returning from an observation tour of the fire area, encountered men coming down through the brush, exhausted, clothing torn, and in need of medical aid. These injured men reported that other men had been trapped by fire on the western slope of Dam Canyon and burned. An investigation proved this to be true.

In the meantime the Mountain Patrol reached the scene at about 3 P.M., at which time the fire was coming over the ridge above the point where the

bodies were afterwards recovered. The captain noticed men running out of the brush with their clothes torn off and their bodies badly burned and lacerated. He improvised a first aid crew, treating approximately 20 of these men for burns. The injured men continued to come in and reported that other men had fallen exhausted in the brush on the western slope of the ridge. A crew was hastily organized to go back over trails to see if any such men could be recovered. The rescuers were warned to keep a sharp lookout in event the fire came over the ridge, and to keep means of escape in mind if this occurred.

The fire was brought under control at about 4:30 P.M., and the work of recovering the dead bodies occupied the fire department until 1 o'clock the following morning. When the final check-up was made, 26 bodies had been found and more than 150 had been treated for burns and other injuries. Two of the injured victims were so badly burned that they died later in the hospital.

The loss of life in this fire may be attributed to a back-fire which was set by someone, and when the men working along the western slope of Dam Canyon realized their danger, the two fires were approaching each other at great speed. The cyclonic action which accompanies a conflagration was present, and the men, finding themselves trapped, did not know which way to run. Some ran along the slope and downward, the majority of these escaping with severe burns. Others tried to escape the way they had come, up the side of the mountain, and the fire caught them. It was testified that in the space of approximately one minute this entire pocket, 25 acres in extent, was in flames.

A survey of the burned area was made by the County Surveyor on October 6 and the extent of the fire, thus determined, was 46.83 acres.

### Conclusions.

The hazards of brush fire fighting are recognized as serious by the Los Angeles Fire Department, and officers and members of the department have been schooled in the proper procedure for combating such fires. In the case of this fire, after the arrival of the fire department, practically every person who entered the area was warned by department officers to proceed with care and not to expose themselves needlessly in perilous positions from which escape would be difficult.

The very large number of untrained workers who responded to the first call of fire made their proper supervision difficult, if not entirely impossible. Even had every park employee been trained in the practical aspects of fire fighting, the result might still have been disastrous, for this vast army of laborers (estimated at more than 1000) was too large to keep in hand.

# The Tillamook Forest Conflagration.

By Lynn F. Cronemiller,
State Forester of Oregon.

The great Tillamook conflagration, starting August 14, 1933, was the most destructive fire Oregon has experienced in sixty-five years. Originating on privately owned timberlands, and sweeping through the finest virgin forest in Oregon, it consumed in eleven days more than 10,000,000 board feet of timber, chiefly Douglas fir, having a potential value of approximately $200,000,000. It burned over approximately 300,000 acres. It claimed one life, a young Civilian Conservation Corps worker from Illinois, and a score or more received serious injuries. Three thousand men battled to hold back the fire, which sprinkled the coast cities of the Pacific Northwest with ashes and charred needles.

### Story of the Fire.

A brisk northeast wind whipped through the Gales Creek Canyon in northwestern Oregon on Monday morning, August 14, 1933. By noon the humidity was so low and the fire hazard so great that loggers closed their operations. That is, all but one, who decided to haul in just one more log before closing for the day. As this last log, a large Douglas fir, crashed to the landing it ground its way across a cedar windfall directly in its path and a tiny wisp of smoke curled into the air.

A fire call was sounded and frantically the entire logging crew strove to control the flames, but a freakish wind caught up the burning brands and carried them into the adjoining slash. The fire spread with explosive force and soon, in spite of the efforts of the loggers, a dense smoke column billowed out of the canyon. Hoffman Lookout, ten miles to the northeast, and Saddle Mountain, eight miles to the south, sent their urgent calls to fire patrol headquarters at Forest Grove, asking that all available help be sent to Gales Creek.

Meanwhile all available men from adjoining mills and logging camps were rushed to the scene of the fire and in a very short time men and tools were on their way from headquarters at Forest Grove. A call was sent to the nearest Civilian Conservation Corps camp for 100 men. Grimly these

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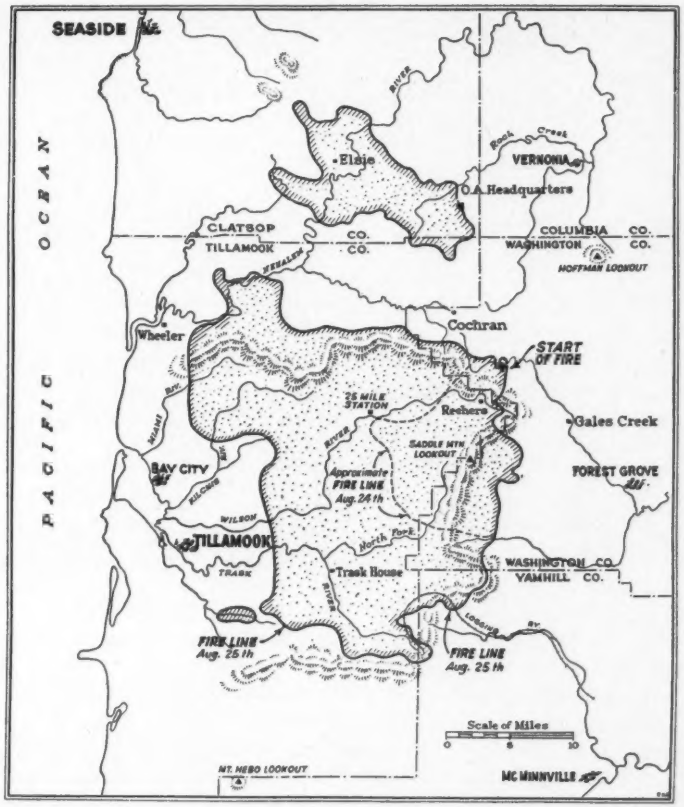
Glossary of Terms. For the convenience of readers who may not be familiar with forest fire nomenclature, the following explanation is given of some of the special terms used in this article.—Ed.

crowning — spread of fire through upper parts of trees, as distinguished from spread along ground.
slash — tops, limbs and other waste left after logging operations, highly combustible.
snag — dead tree or brush, much higher combustibility than merchantable timber.
spot — start of secondary fire by embers from the original fire.
trailed — segregation of fire by a fire line or trail along the ground from which combustible material has been removed.




hastily assembled crews fought to trench the fire and hold it, but the fire jumped to the tops of snags 150 to 200 feet high, and flaming bark sailed into the air to be carried far into the adjoining timber.

Shortly after six o'clock on the evening of the start of the fire, the patrolman at Reehers, near the summit of the Coast Range several miles to the south, reported a spot fire on the south side of the Wilson River road. At the same time charred sticks, leaves and other light débris were falling in that section. Men were sent in truck loads to attack this new fire and worked desperately all through the night. In the morning fresh crews replaced them. Fire lines were built and lost again and again as the fire went afresh into the crowns of the trees, but the fight continued day and night.

Toward the end of the week a slight rain fell and the fire fighters worked with renewed vigor. By Saturday evening, August 19, the fire was practically

*U. S. Forest Service.*

**The Tillamook forest conflagration at its height on the afternoon of Aug. 25, photographed from a distance of one mile. This picture shows only a small part of the burning area.**

trailed and indications were that it would be put under complete control. But on Sunday afternoon, hot dry winds again swept out of the north and east, and again the fire worked into the crowns. Hissing and roaring, it rushed on through the timbers, showering myriads of burning brands far ahead. Fire lines were again wiped out. A wall of flame and smoke threatened the Reeher Camp, and two other camps containing 200 C.C.C. boys lay in the fire's path. A runner was sent to order them out and they evacuated just in time.

About this same time, 175 men were fighting the fire in the vicinity of Saddle Mountain. The terrifying roar of the crown fire, intermingled with the crash of falling trees, descended upon them. They became panic-stricken. Some dropped their tools and started to run. Others stood awe-stricken and terrified. But the foremen in charge kept their heads. Calming their crews, they led them through the brush, over logs and up the mountain side. After a mile, with the noise of the fire ever getting closer, and ashes, leaves and cinders falling all about them, the men broke out into an old burn, and safety.

The call went out for more men and by the end of the week, the hot dry winds still fanning the flames, there were nearly 3000 men at work. Forest Grove became as an active wartime headquarters. The army established a supply depot from which to transport food. All night and all day trucks loaded with men, food and equipment rolled to the fire lines.

On the tenth day came the promise of a break in the weather. The wind died down, the humidity rose. But before daybreak the next morning, the

*U. S. Forest Service.*

**Left: Heavy Douglas fir timber, typical of the burned area. The tree at the right is 7 ft. in diameter. Every tree in this picture has been killed. Right: Twenty years later. What the unsalvaged portions will look like.**

25th, a hard wind began to blow directly out of the east, and the humidity went down to an unbelievably low figure. Through past experience with fires, wind, and humidity, the men who were in charge of the fight knew what was in store. Cars were immediately sent to get all fire fighters and all families away from the west side of the fire. Through blinding heat and smoke, with burning brands and débris falling around them, the cars made their way to safety. On the road large droves of deer were passed, walking or running, forgetting their terror of man in the greater terror of fire.

With daylight a spectacle unfolded that has seldom fallen to the lot of man to witness. Over a 15-mile front a solid wall of flame leaped through the tops of the trees. Upward in great clouds the smoke belched, rolling and churning to a height estimated by aviators at 40,000 feet. The wind was so terrific that pilots refused to take their planes near the fire, fearing that they would be drawn into the flames.

Enormous Douglas fir trees were uprooted. Trees and brush, tossed by the cyclonic fury of the wind, lay in twisted, tangled masses. A terrible suction, just ahead of the flames, caused great trees to fall directly toward the fire to be immediately engulfed. Rock cliffs were cracked by the terrific heat. Loosened material rolled down the mountain sides in avalanches.

Two men stood on the Mount Hebo Lookout, a few miles south of the fire, and watched a ball of flame rush high into the air. Then east winds caught it and carried it westward, to fall seven miles ahead of the main fire in a dense stand of spruce timber. Almost instantly another crown fire developed and rolled on toward the coast. By mid-afternoon the fire had spread over a twenty-five mile front.

Early in the day the coast region for a distance of thirty miles along the front of the fire became overcast with smoke. Objects took on a weird unnatural appearance as the sunlight filtered through, and later a dense, peculiar darkness engulfed the country. City lights were turned on and chickens went to roost. Motor cars attempted to pick their way in a smoke denser than any fog that ever rolled in from the Pacific. Ashes, fir needles, leaves and charred twigs fell so thickly on the coast cities that they could be scooped up in shovels. On the incoming tides of the Pacific, great masses of débris were carried and deposited along the beaches to a depth of over two feet.

Then to add to the woes of an already weary fire fighting organization, an incendiary set fire to a slashing about six miles to the north. Hundreds of men were sent in. They had hopes of controlling it before night, but weather conditions were against them. The east winds carried it through the slashings and into the green timber. It immediately crowned and by evening the head of the fire was eighteen miles away from the point of origin. Over 60,000 acres of timberland were burned — an immense fire in itself — but dwarfed in size and importance by the terrific fire to the south.

At last, on the eleventh night, a fog — the first one in days — drifted in from the coast. By morning the fire was again on the ground and under control, but the 40,000 acres destroyed up to August 24 had grown to a total of approximately 311,000 acres — just twenty hours later.

But one human life was lost, that of a C.C.C. boy from Illinois. He was patrolling the fire line one night with another youngster and they sat down to rest. Without warning, a tree fell and pinned them to the ground, instantly killing one and severely injuring the other. The destruction to animal life was appalling. Charred bodies of many deer were found lying with their heads to the west, struck down as they fled.

The difficulties in fire fighting were almost insurmountable. Many areas were so badly cut up by rock cliffs and steep hills as to make fire line construction an impossibility. No roads bordered the fire on either the north or south, and only stub roads on the east and west. Packing became a problem. A warm, humid climate had developed a forest of the rankest growth. Ancient Douglas fir trees in many places formed a stand as heavy as 100,000 board feet to the acre. Underbrush consisting of vine maple, salal, devil's club and other forestal growth made an almost impenetrable mass. The accumulation of decayed vegetation, peat-like in character, lay from six inches to over a

foot in depth. First swampers cleared away the underbrush. Then came the men with shovels and hazel hoes, digging a two-foot trench down to mineral soil. It was slow work, but the entire east side was trenched and held.

The Tillamook fire has become history, but its effects upon the welfare of the citizens of Oregon will be felt for many years. Fourteen and one-half billion board feet of timber were within the exterior boundaries of the fire. Over ten billion feet have been killed. Based upon pre-depression prices, the owners face a possible loss of $20,000,000. But the manufactured products placed upon cars would have brought upward of $200,000,000 into the State. The only hope lies in salvage, but the enormous amount of timber involved makes it impossible to log it all before decay and insects take a large toll. Isolation and expense of development under present conditions place an impossible barrier before the private interests. It is a stupendous problem and necessitates concerted private and public action to remove all possible values.

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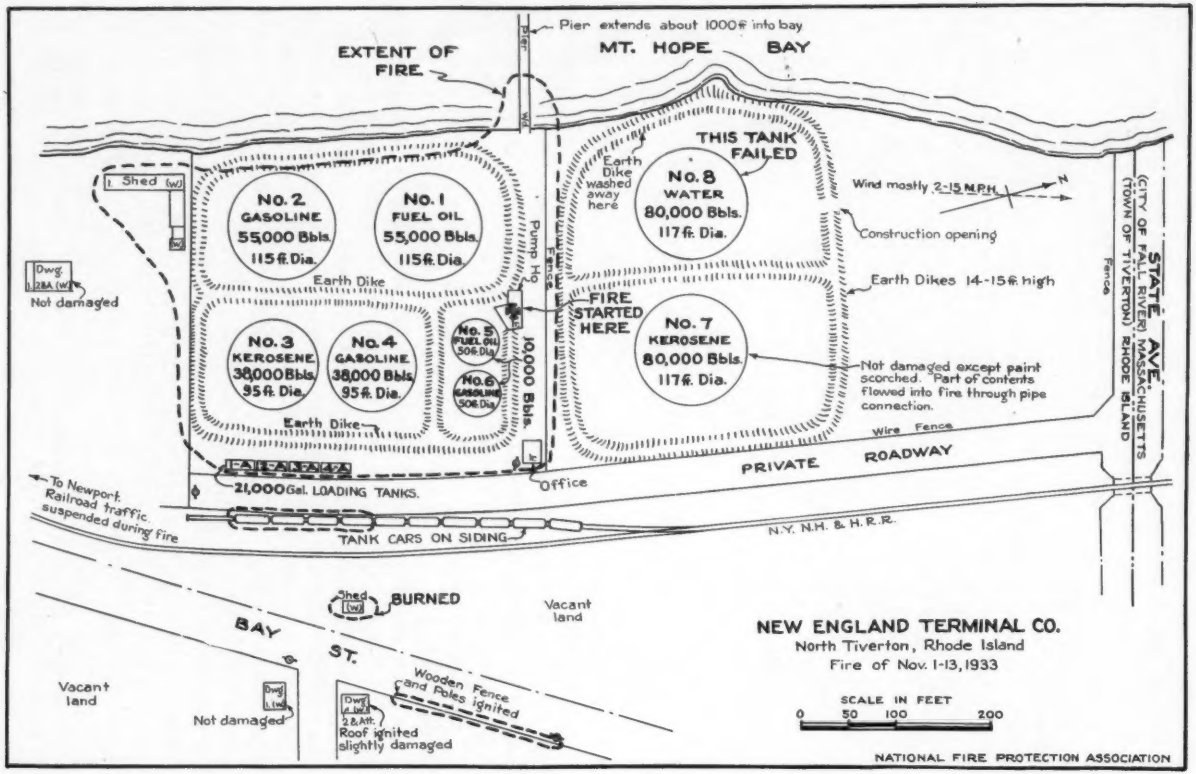
# Tiverton, R. I., Oil Fire.

The marine oil terminal of the New England Terminal Company, North Tiverton, Rhode Island, was largely destroyed by fire that started at about 9 A.M. on Nov. 1, 1933, following the collapse of a new 80,000-barrel tank which had been filled with sea water for testing. Three men were killed in the collapse of the tank. The ensuing fire burned for several days, causing damage variously estimated at $700,000 or more. A total of nearly 5,000,000 gallons of gasoline, kerosene and fuel oil was destroyed. With the exception of one tank, and the pier, the entire plant was a total loss.

The property was located on the shore of Mount Hope Bay, just south of Fall River, Mass., in a sparsely built area as well suited for oil storage as any location likely to be found on tide water near population centers and with suitable transportation facilities. Despite the severity of the fire the damage to surrounding property was relatively small, there being no important buildings close to the plant. Features not in accordance with the recommendations of the N.F.P.A. Committee on Flammable Liquids, and lack of any suitable fire protection were important factors in the severity of the fire.

The arrangement of the plant and its environs are shown by the accompanying map and photographs. Gasoline, kerosene and fuel oil were received

This report has been prepared from data furnished by the New England Insurance Exchange (Member N.F.P.A.), the Eastern Underwriters Inspection Bureau (Member N.F.P.A.) and the Inspection Department of the Associated Factory Mutual Fire Insurance Companies (Member N.F.P.A.), supplemented by observations at the fire by Robert S. Moulton, Technical Secretary, N.F.P.A.


Pier extends about 1000ft into bay
EXTENT OF FIRE
MT. HOPE BAY
Pier
THIS TANK FAILED
Earth Dike washed away here
No. 8 WATER 80,000 Bbls. 117ft. Dia.
Wind mostly 2-15 M.P.H.
N
Construction opening
Earth Dikes 14-15ft. high
No. 2 GASOLINE 55,000 Bbls. 115ft. Dia.
No. 1 FUEL OIL 55,000 Bbls. 115ft. Dia.
Earth Dike
Pump House
FIRE STARTED HERE
No. 7 KEROSENE 80,000 Bbls. 117ft. Dia.
Not damaged except paint scorched. Part of contents flowed into fire through pipe connection.
No. 3 KEROSENE 38,000 Bbls. 95ft. Dia.
No. 4 GASOLINE 38,000 Bbls. 95ft. Dia.
No. 5 FUEL OIL 50ft. Dia.
No. 6 GASOLINE 50ft. Dia.
10,000 Bbls.
Earth Dike
Wire Fence
Fence
STATE AVE. (CITY OF FALL RIVER) MASSACHUSETTS (TOWN OF TIVERTON) RHODE ISLAND
PRIVATE ROADWAY
Office
21,000 Gal. LOADING TANKS.
To Newport. Railroad traffic suspended during fire
TANK CARS ON SIDING
N.Y. N.H. & H.R.R.
Shed (w)
Dwg. 1 2 8A (w)
Not damaged
Shed (w)
BURNED
Vacant land
BAY ST.
Wooden Fence and Poles ignited
Vacant land
Dwg. 1 (w)
Not damaged
Dwg. 2 (w)
2 8 Attr.
Roof ignited slightly damaged
NEW ENGLAND TERMINAL CO.
North Tiverton, Rhode Island
Fire of Nov. 1-13, 1933
SCALE IN FEET
0 50 100 200
NATIONAL FIRE PROTECTION ASSOCIATION

from tankers or barges, pumped to the storage tanks and loaded in tank cars and trucks for wholesale distribution.

The sizes, capacities and contents of the several tanks are shown by the accompanying table. It should be noted that for the most part tanks were only partly full, some of them having only a few feet of liquid in the bottom. This fact may have contributed to the spread of fire, a tank which is only partly full being presumably more readily subject to ignition from exposure fire than one that is full. The large vertical tanks were all approximately 30 feet high with the exception of Nos. 7 and 8, which were approximately 40 feet high.

### Tank Capacities and Contents.

(As reported by representatives of the company)

| Tank No. | Product | Capacity | | Quantity at Start of Fire—Gals. |
|---|---|---|---|---|
| **Vertical Storage Tanks.** | | **Bbls.** | **Gals.** | |
| 1. | Fuel Oil ..... | 55,000 | 2,310,000 | 1,786,937 |
| 2. | Gasoline ..... | 55,000 | 2,310,000 | 96,760 |
| 3. | Kerosene ..... | 38,000 | 1,596,000 | 267,498 |
| 4. | Gasoline ..... | 38,000 | 1,596,000 | 552,530 |
| 5. | Fuel Oil ..... | 10,000 | 420,000 | 379,207 |
| 6. | Gasoline ..... | 10,000 | 420,000 | 69,622 |
| 7. | Kerosene ..... | 80,000 | 3,360,000 | 1,581,886 |
| 8. | ..... | 80,000 | 3,360,000 | (Under test with salt water) |
| **Horizontal Loading Tanks.** | | | | |
| 1A | Gasoline ..... | 500 | 21,000 | 13,755 |
| 2A | Kerosene ..... | 500 | 21,000 | 6,324 |
| 3A | Kerosene ..... | 500 | 21,000 | 7,015 |
| 4A | Fuel Oil ..... | 500 | 21,000 | 5,075 |

**Piping and Tank Cars.**

There was a total of 7649 ft. of piping, of which 7106 ft. was 8 in. and the balance 6 and 4 in. This contained 6395 gallons of gasoline, 6465 gallons of kerosene, and 6170 gallons of fuel oil, a total of 19,030 gallons.

Two tank cars on the siding contained a total of 16,200 gallons of gasoline.

The vertical tanks were all surrounded by earthen dikes with a height of 14 to 15 feet and enclosing sufficient area to hold the entire contents of the tanks. A serious defect was a break in the dike at the location of the pump house adjacent to tank No. 5. The dike was not continuous at this point, the pump house wall being depended upon to form a part of the dike.

The loading tanks, Nos. 1A, 2A, 3A and 4A, were horizontal tanks on unprotected steel supports, with no dikes.

All of the tanks were nearer to each other than one diameter minimum spacing called for by N.F.P.A. standards with the exception of tank No. 7, which was adequately separated from the nearest tank involved in the fire.

*Eastern Underwriters Inspection Bureau.*

**Wreckage of Tank No. 8, which collapsed while under test.**

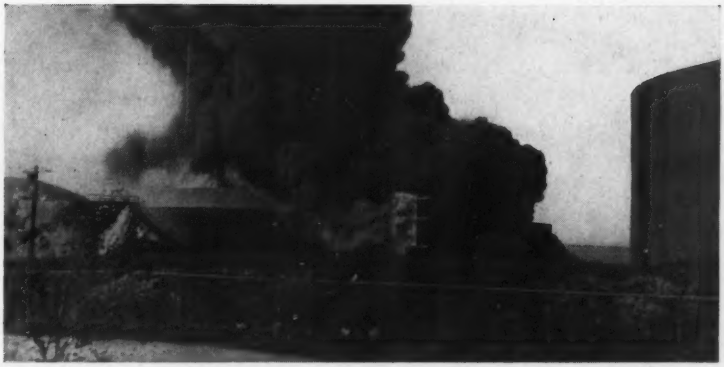
It is significant that tank No. 7 was the only one not destroyed. It is also noted that tank No. 7 was equipped with vents of approved type, with larger capacity than on the other tanks.

### Collapse of the Tank.

A new 80,000-barrel tank, 117 ft. in diameter, 42 ft. high, shown on the plan as tank No. 8, had prior to the fire been filled with sea water to within a foot of the top for test purposes. This tank was similar to tank No. 7, but was of electrically welded construction. Men were at work stopping leaks in the shell of the tank.

While this work was going on one of the vertical seams in the shell at the lower part of the tank gave away and the entire tank suddenly collapsed, releasing its contents. While the dike had sufficient height to stop the water if it had escaped slowly, the sudden collapse of this large tank resulted in a wave which carried quantities of water over the dike. The dike washed away on the side toward the bay, but this did not prevent overtopping the dike by water on the side toward the pump house. The force of the water was such that parts of the tank were carried for distances as great as 75 feet, and a heavy electric welding machine was washed over the dike. Three men who had been working on the top of the tank were drowned or killed by impact.

There are not sufficient data available at this writing to make any positive statement as to the cause of the tank failure. Unequal settlement was first suggested as a contributing factor, but observations after the collapse have not been indicative of settlement of the foundation. It appears that the tank was designed in accordance with N.F.P.A. standards as respects the thickness of the steel in the shell. The owners of the property are reported to have brought suit against the concern erecting the tank, alleging defective



*Factory Mutuals.*

**Looking west, about 10 A.M., November 1. Fire around pump house had not yet extended to tanks Nos. 5 and 6 at left. Note dome shaped roofs, which with inadequate venting resulted in building up internal pressure. Tank No. 7 at right was not involved.**

welding. In the absence of N.F.P.A. standards on tank welding (under consideration by the N.F.P.A. committee on Flammable Liquids prior to the fire, but not yet available) there is no basis for comparison of this detail with published N.F.P.A. recommendations.

Certain points of differences between welded and riveted tanks may be of interest in connection with this tank failure. Defects in riveted tank construction are usually readily apparent. With welded construction, however, visual inspection may not be indicative of the quality of the weld. The stopping of leaks in riveted tanks is by caulking edges of the plates beyond rivets, with no work done on metal that is under stress during a test. In the shell of a welded tank all the metal is under stress during a test, and any work done in stopping leaks is performed on metal that is under stress. If there is any serious defect in a weld the hammering operation might cause it to open. If welding is done while the steel is in tension the heat might weaken the metal or might cause local temperature stresses to the point of failure. While these points may have no bearing on the collapse of the tank at Tiverton and should not be construed as reflecting upon the successful record of other welded tanks heretofore erected, they are the subject of extensive discussion in connection with future standards for welded tank construction.

### Start of the Fire.

A considerable quantity of water overtopped the dike and rushed down into the gulley between dikes where the pump house was located. The force of the water and the débris carried by it apparently ruptured piping which was laid on the top of the ground without special protection. Gasoline and oil were released. At the same time it appears that electric pumping equip-

*Boston Herald.*

**Airplane view of fire about 11 A.M., November 1. Fire burning at pump house and in diked area around tanks Nos. 5 and 6. Wreckage of tank No. 8 in left foreground. Two-story building at street corner beyond railroad, and sheds in the right foreground were ignited by exposure later in the day. There was little or no wind during the early hours of the fire.**

*W. W. Coolidge, Fall River Herald-News.*

**Looking north along the shore of Mount Hope Bay, showing oil burning on the surface of the water. The shed in the right foreground was destroyed.**

ment in this building was affected. Eyewitnesses report a sparking or flashing in the pump house. This condition obtained for perhaps ten or fifteen minutes after the tank collapsed before the start of the fire. Employees realized the danger, but owing to the general confusion and the fact that those killed or injured in the fire required first attention, nothing was done to prevent fire in the pump house.

Converging in this pump house were pipes from all the tanks on the property. These pipes were equipped with valves at each tank and at the pump house, but at the time of the fire oil was being pumped between tanks and the valves at the tanks were open. Thus the entire contents of all the tanks might be released in the pump house area by the breakage of pipes, in addition to the 19,030 gallons in the pipes. It is said that at an early stage in the fire an employee closed the valves of all the tanks except No. 7.

## Spread of the Fire.

Owing to the break in the dike around tanks Nos. 5 and 6 at the pump house, gasoline and oil flowed into this area and subjected these tanks to severe heat. While the tanks were of all steel construction with gas-tight roofs, ignition soon followed, owing to the severity of the exposure fire. Apparently in these and other tanks ignition occurred through the extreme heating of the tank shell above the liquid level, joints opening at the roof line or in the shell.

Shortly after tanks Nos. 5 and 6 were involved oil flowed down the gulley between the dikes of tanks Nos. 1 and 8, and burned on the surface of the water near the shore. The shore end of the wooden pier was destroyed.

Owing to excitement and confusion, and the great volume of smoke, observations of eyewitnesses do not give any exact information as to the

*W. W. Coolidge, Fall River Herald-News.*

**Looking north about 3 P.M., November 1. The large tanks Nos. 1 to 6 were all involved at this time, and the horizontal loading tanks at right were severely exposed. The dwelling at the left, 175 feet from the nearest burning tank, was not damaged. Note pigeons on roof.**

sequence and manner of ignition of the other tanks. It appears, however, that fire spread from tanks Nos. 5 and 6 to Nos. 4, 3, 2 and 1 in the order named.

The loading tanks 1A, 2A, 3A and 4A, and the tank cars on the siding were ignited during the afternoon and evening from exposure due to the burning of tanks Nos. 3 and 4. All the tanks on the property, except No. 7, were involved by the night of November 1.

### Fire Department Operations.

The Fall River Fire Department had been summoned for rescue work before the fire broke out. Tiverton firemen saw the smoke and responded promptly. There was, however, no foam or other equipment suitable for fighting oil fires available either at the plant or in the equipment of the fire companies that first responded, and the fire was practically beyond control

*Boston Herald.*

*International.*

**Foam equipment was hurriedly assembled and brought into play in the afternoon of November 1. Upper picture shows a foam stream in operation. Lower picture shows men carrying containers of foam powder. The rate of foam application was totally inadequate for a fire of this magnitude.**

from the start. Hose streams were used in the early stages of the fire in an endeavor to cool adjoining tanks and prevent ignition, but seem to have had little effect.

During the day foam equipment from near-by cities was hastily assembled and four tank cars of foam solution were brought from another oil storage plant within a few miles. Two foam streams were put into operation in the early afternoon. These were played on burning oil in the dike areas around tanks Nos. 5 and 6, but were ineffective to control a fire of such large area. A sudden burst of flame compelled retreat. A number of the firemen were burned, but none seriously. When the fire could again be approached, pumpers drew from the tank cars and delivered the two liquids through single hose lines to a siamesed connection to form a good foam stream, but realizing the futility of attempting to control the fire with the amount of foam available, the firemen withdrew during the evening and confined their further efforts to the protection of exposed property. Several pumpers arrived from near-by towns, but were not used, as the fire was beyond control.

### Behavior of Tanks.

There were a number of so-called explosions during the fire. However, examination of the ruins after the fire fails to show any evidence of a true explosion of a tank. It is probable that the occurrences that were reported as explosions consisted in the rapid release of large quantities of vapor which, because of limited air supply, did not burn immediately, but subsequently ignited. At one time during the evening of November 1 flame was reported as extending a quarter of a mile overhead.

The vents on the tanks involved were presumably not adequate to relieve the pressure generated by the severe heat. The construction of flat roofs, however, is such that with an increase in pressure the tank should vent itself by an opening up of the seam between the shell and the roof before generating dangerous pressure. This is apparently what happened with most of the tanks, although in one case the release of pressure was so sudden that flame extended horizontally for a considerable distance. This may have been tank No. 5 or No. 6, which had dome shaped roofs.

The damage to the loading tanks, Nos. 1A, 2A, 3A and 4A, was characteristic of a horizontal tank on unprotected steel supports. These tanks were severely exposed and eventually ignited. The unprotected steel supports collapsed, dropping the tanks, as may be seen from the accompanying photograph. Considerable pressure was presumably built up in these tanks, and the release of this pressure by the blowing off of manhole covers or the opening of seams may have projected flame for a considerable distance and been reported as an explosion. It is also possible that explosions may have occurred in sections of piping between these tanks where valves were closed.

*Factory Mutuals.*

**Looking northwest on the morning of November 2. Note loading tanks, Nos. 1A, 2A, 3A and 4A, which fell when their unprotected steel supports failed. In the background may be seen tank No. 1 still burning furiously and tank No. 4, which was burning on the far side when the picture was taken.**

Of the ten tank cars on the side, four or five were badly damaged and the others damaged to some extent. While newspaper reports state that these tank cars exploded, there is no evidence of anything more than burning at the vents.

There was little if any noticeable difference in behavior of the gasoline, kerosene and fuel oil tanks involved in the fire, either in manner of ignition or character of burning.

### Damage to Surrounding Property.

The extent of the damaged property is shown on the accompanying map. To the south some frame sheds within 50 feet of tank No. 2 were ignited, but a frame dwelling about 175 feet away was not damaged. On the east a small frame shed was destroyed, one house was ignited, but the fire was extinguished with slight damage; also a wooden fence was ignited. The house was about 260 feet from the large burning tanks, Nos. 3 and 4, but loading tanks and tank cars were nearer, the latter being at a distance of approximately 175 feet. Other buildings in the vicinity were not involved, although as a precaution all dwellings in the immediate vicinity were vacated during the fire. A maximum wind velocity of 15 miles per hour was reported during the fire, but on the first day, when the heat was most intense, the wind was not sufficient to be a factor as regards exposed buildings.

### Second Day of the Fire.

On the morning of November 2 tanks Nos. 2 and 3 were completely burned out and collapsed. Likewise the fire in the loading tanks was practically burned out. There was no fire around the tank cars. Tank No. 1,

*Eastern Underwriters Inspection Bureau.*

**Looking southwest across the ruins of the pump house and Tanks Nos. 5 and 6 on November 3. Note broken piping, and gap in dike. Tank No. 4 at right continued to burn until it collapsed on November 13. Note dwellings in the background. One of these was ignited by exposure, but the fire was extinguished with slight damage.**

containing fuel oil, was still burning furiously and the entire area and the dike around tanks Nos. 5 and 6 was still burning with as great an intensity as on the preceding day. This is accounted for by the fact that kerosene from tank No. 7 had been fed into this area through a broken pipe connection. Finally the valve on tank No. 7 was closed, but the fire around tanks Nos. 5 and 6 continued to burn until November 3.

Tank No. 7 was exposed to an extent sufficient to scorch the paint, and it was reported at one time that oil ignited around small leaks at a manhole. This fire was extinguished, however, and the tank came through the fire with practically no loss, except for the escape of part of its contents through the pipe connection. This tank, 117 feet in diameter, was 140 feet from the nearest burning tank, but probably under 100 feet from the burning oil around the pump house.

Tank No. 4 remained standing through most of the fire. Shell plates were warped and wrinkled from the intense heat. Vapors were burning at the roof line and from a leak or broken pipe at the bottom of the north side, but the tank itself did not seem to be otherwise involved. This burning continued for ten days after the main body of the fire had burned out, and on November 13 a mild explosion occurred which completed the demolition of the tank.

The probable explanation of this explosion is that as the liquid level receded and the temperature inside the tank began to decrease, air was drawn into the tank, forming a vapor-air mixture which finally exploded.

# Fire Control for Passenger Vessels.

By George G. Sharp,
Naval Architect.

It is unfortunate that so much of the consideration given recently to the fire hazard on passenger ships has been in the light of the many spectacular fires of the last few years. While one cannot escape the conviction that such disasters should not have occurred, consideration of the problem in the atmosphere created by these fires is apt to lead to laying the emphasis too greatly upon providing the means for dealing with a conflagration. This, it would appear, has had the effect of diverting attention from the necessities of the situation and leading to such suggestions as the floodable screen, greater subdivision by additional fire-screen bulkheads to reduce the area of fire zones, and other means of a like nature, all of which suggest a groping for some means of controlling a well-established fire of high temperature.

The suggestion of one hundred per cent sprinkler system protection has also been made and apparently has met with a great deal of opposition. Provided the usual types of materials and methods of construction within the existing or reduced zoning systems are to be maintained, it is difficult to avoid the feeling that the sprinkler system is the best, if not the only, means whereby fires may be kept under any reasonable control.

It is not the intention here to go into any statistics relating to ship fires and their causes, or to discuss in much detail defects in the existing arrangements and other related matters, all of which have been recorded elsewhere and are no doubt familiar to those interested.

Notwithstanding the fine records of many long established steamship lines, one must be careful not to be lulled to inaction by these records, since there is evidence of potential danger. On the other hand, being stampeded, by the consequences of conditions which need not exist, to striving for the unattainable goal of one hundred per cent protection, leads back to discouraged inaction.

Recent experience seems to indicate inherent weakness somewhere leading to the failure of the apparently adequate statutory detection and extinction systems to provide for control of an incipient fire.

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Extracted from paper read before the Society of Naval Architects and Marine Engineers, New York, November 16, 17, 1933. The complete paper will appear in the Transactions of the society. The author is chairman of the conference committee of the N.F.P.A. Marine Committee which prepared the Recommended Regulations Governing Fire-Resistive Construction Aboard Vessels presented to the Association in 1933 (Proceedings 1933, page 184). In condensing this 48 page paper for the Quarterly much detail has necessarily been omitted.

The provisions needed to secure fire safety on passenger vessels have been carefully studied by the N.F.P.A. Marine Committee through various conference committees. Recommended Regulations Governing Fire-Resisting Construction Aboard Vessels in Ocean and Coast-Wise Service were presented by the Marine Committee at the 1933 annual meeting. Reference should be made to these recommended regulations (Proceedings 1933, page 184) in connection with the present discussion. Attention is particularly directed to the diagram of fire bulkheads on a 630-foot passenger vessel appearing on pages 186-188 of the Proceedings. Briefly, these recommended regulations provide main subdivisions designated as Class "A-1" bulkheads having a function similar to that of fire walls in buildings, an additional subdivision designated as Class "A" bulkheads designed for enclosures around vertical openings, and for storage and working spaces, and Class "B" bulkheads including stateroom partitions and other enclosures within the main divisions. Appropriate doors are specified for the several classes of bulkheads, also draft doors to protect fire doors until they can be reached for manual closing, and to subdivide long corridors.

In the consideration of any methods whereby an outbreak of fire on board a passenger vessel might be controlled, the following conditions may be assumed:

That, due to carelessness, short circuits, or numerous other causes, fires will occur in the accommodation of passenger vessels regardless of any regulations, campaigns of safety, education, or other precautions.

That fires of whatever origin (except explosions), while they cannot be considered of minor importance under existing conditions, are, at their inception, usually of low temperature.

That the temperature of an established fire is considered to be about 1700 degrees.

That draft is the most active agent in the rapid establishment of fire, and that the construction of cabin and other enclosures and linings in the usual manner is such as to promote draft above and behind linings. After the starting of a fire the progressive breakdown of the walls and linings of these enclosures happens so rapidly that the fire is well established within the period between the registering of an alarm and the active functioning of the available fire extinguishing system and apparatus.

That there is no such thing as 100 per cent protection, as a result of the utilization of the best materials and methods of construction at present available, which could be considered as meeting any reasonable requirements of weight, cost and practicability of construction.

That cabin or other enclosure "B" bulkheads within the zones provided by the statutory fire screen "A-1" bulkheads are usually constructed of untreated wood with painted or other finished surface, are easily ignited, highly inflammable, and provide, along with the furnishings, excellent fuel to generate a fire of high temperature.

That furniture and furnishings, together with passengers' effects, are usually of a flammable nature.

That the substitution of metal or treated wood furniture would have the effect of reducing the supply of fuel supporting a fire and, while helpful, would not in itself prevent its rapid spread.

Being reasonably assured that an outbreak of fire cannot be prevented, that 100 per cent protection is not an immediate possibility, and that fire will spread, due to the lapse of time between its detection and the functioning of extinguishing systems, and to the difficulty of reaching the fire on account of smoke and fume conditions, it remains to be considered what are the essential factors governing methods whereby fire might be controlled.

It would appear that, if the means for giving effect to the following brief outline of provisions for detection and extinction and for construction and draft could be developed, control of fire might then be more confidently predicted.

Detection and Extinction: Provision of a reliable automatic alarm system, having a detector in each cabin or other "B" enclosure and registering in a central control station, or pilot house.

Provision of a 24-hour watch in the central control station whether the vessel is at sea, in port, or laid up.

Provision for an adequate patrol of public rooms, corridors and spaces not served by the automatic alarm.

Provision for two powerful jets simultaneously directed at any part of the ship; also an additional jet on the decks next above and below, together with statutory fire extinguishers.

Construction and Draft: Provision for confining fire within the cabin or other "B" enclosure bulkheads by use of such materials and construction as to insure maintenance of their integrity for a sufficient period of time (say 20 minutes) after the alarm registers to allow fire fighters to reach the fire location and to get extinguishing apparatus into operation.

Public and other spaces (without automatic detection) of such construction as to maintain their integrity after an outbreak of fire for the period between patrol rounds.

Provision for elimination of all draft to each cabin or other "B" enclosures, except such as might be created by open airports, door or ventilation. This to apply to spaces behind linings for the extent of each "B" type enclosure and at suitable intervals in public spaces.

Provision of a means for shutting down mechanical ventilation from the pilot house or central control station immediately upon receipt of alarm.

## Draft.

Draft is the most active agent in the development of an incipient fire into one of sufficient intensity to bring rapidly into play all the dangerous factors leading to disaster.

The ranges of cabin or "B" enclosures are conceded to be the most vulnerable part of the vessel, also the most difficult to handle after an outbreak of fire; consequently it is considered as an essential of any system of control that each of these units should be capable of maintaining its integrity for a reasonable period of time for the reasons already stated.

Obviously they cannot be considered to have accomplished this purpose, if in the meantime fire and smoke can escape over the top of the bulkheads through open spaces and behind linings, providing additional draft for in-

creasing the intensity of the initial fire and setting fire to adjacent rooms in all directions, thus producing the conditions in a very few minutes that are so difficult, if not impossible, to control, as has unfortunately been demonstrated too often.

### Construction.

Cabin and like "B" type enclosures of the usual construction and materials will obviously not meet the essential requirements as outlined above.

A series of tests has been made to obtain some definite information as to the action of fire under varying conditions of draft, etc., that might be expected in "B" enclosures as well as to obtain some preliminary information on the performance of a number of the fire-resisting materials available which were believed to be suitable to meet these essential requirements. These tests are described in some detail later in this paper.

There are a great number of materials available for bulkheading that will offer the necessary resistance to fire for the desired period, if properly constructed. Fire-resisting materials for furring behind cabin bulkheads are preferable but not essential with fire-resisting lining and a limited amount of furring. There are also a great variety of tested fire-resisting wood doors available. However, only hollow steel and aluminum doors were used in Tests Nos. 1 and 2. These were considered to be quite satisfactory. It was noted in Test No. 1 that after the enclosure had thoroughly cooled down the steel door fitted, and, together with hinges and lock, operated satisfactorily. Hollow steel doors on certain types of vessels would be somewhat heavy.

Public rooms, on account of their large area, combined with height and the necessity for a certain amount of freedom in obtaining good architectural effects, make the control of fire within these spaces somewhat more difficult, and high temperatures might be reached before fire-fighting apparatus is functioning.

The use of an automatic sprinkler system would be justified in such spaces, if anywhere, and would be particularly useful over large open walls and staircases. However, if proper thought is given to the construction, and if designs are worked out in such a way as to reduce to a minimum the necessity for the use of wood, the danger of fire getting beyond control will not be very great, since public rooms should be, and usually are, bounded by steel (class "A") bulkheads whether by deck house sides, sides of the vessel or transverse structural or statutory fire-screen bulkheads.

In public rooms ceilings should be of fire-resisting materials. In smaller rooms their use might not be essential, though this is a debatable point.

Linings should be of fire-resisting materials. Furring of untreated wood is allowable, but it should, and can, be reduced to such an extent as to constitute no real danger, provided the "B" class linings are fitted close out to the frames in rooms of moderate size.

Where for any reason side walls are not fitted close out to the frames, and the usual heavy furring is used, it should be of fire-resisting material.

Much trouble could be averted by treating side walls in a similar manner to that suggested for class "B" bulkheads.

Beam boxing of hardwood is not considered a hazard of any consequence, if it is not carried through bulkheads in public rooms of reasonable area. Naturally, treated material is preferable.

### Furniture and Furnishings.

The use of metal furniture is not considered an essential in cabin or other "B" enclosures, but its use would be of great advantage in the reduction of the fire hazard. There seems to be no good reason why all beds in the normal staterooms should not be of metal. Wardrobes should also be of metal or other fire-resisting material, thereby protecting the flammable contents for a considerable period.

The use of built-in wardrobes should be avoided, permitting the completion of the four walls of each enclosure without breaks of any kind.

In public rooms any built-in furniture, such as bookcases, sideboard, etc., should be of fire-retarding material. Offices can be dealt with almost entirely in metal.

Officers' and crews' rooms should be furnished entirely in metal.

Portable furniture of untreated wood seems to present no special hazard, but consideration should be given to the use of metal chairs where the number is great in one space, such as in a dining room.

### Economics and General Comment.

It has been estimated that the additional cost that would be incurred in a large passenger vessel by compliance with the tentative regulations of the National Fire Protection Association would be almost one per cent of the cost of the vessel. This is probably very close to the mark, provided no improvement is made in the architectural design looking to the development of more simple forms that would lend themselves to the elimination of wood and simplification of construction.

It is difficult, of course, to conceive of anyone carrying out some of the designs noted in the public rooms of a great many passenger vessels without an extensive and costly use of wood. It is still more difficult to offer any suggestion, if this type of decoration is to be insisted upon, except to have it carried out in fire-resisting materials, thereby increasing expense and weight.

It is doubtful if a proper appraisal of the passengers' taste in such matters has been made by those responsible. It seems to have been overlooked that the passenger has to live more or less in these quarters in many cases for fairly long periods of time and that nothing is more confusing and more

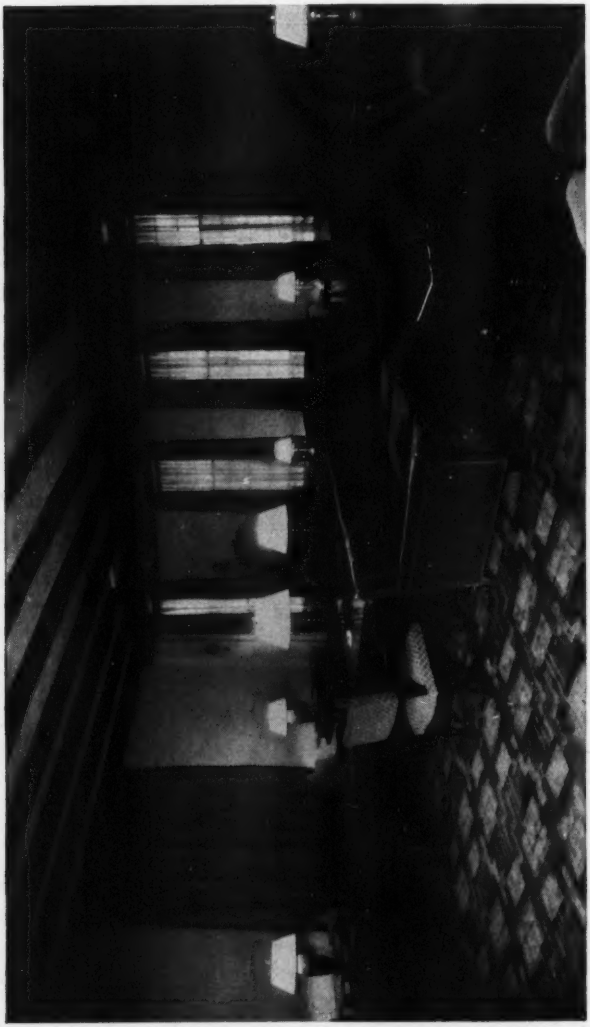


Fig. 1. This photograph of the lounge of the American Scantic Line vessels "Scanpenn," "Scanyork," "Scanmail" and "Scanstates," shows effects that may be obtained with the use of wood minimized and usual decorations omitted. Structural steel deckhouse, lined with hard pressed board primed both sides with fire resisting paint, and face of walls finished with cement base fire resisting composition.

monotonous than the excessive detail of the over-decorated treatments so generally used. The better modern treatments could be dealt with most economically and with a minimum of wood, but the over-decorated modern treatments are even more confusing than the period types. There are some fine examples of the modern style, which are simple and lacking in monotonous detail.

Gems of highly decorated period architecture are beautiful, but it is doubtful if anyone really believes that a museum containing a fairly comprehensive collection of these, even assuming they are gems, would be a desirable place in which to relax on a business or holiday voyage—though this in effect is what is provided in too many cases. May it not be, in the competitive rush to excel in decorative magnificence, that sufficiently penetrating thought has not been given to this very important subject?

It is suggested that, if the luxury be confined to furnishings of good taste and if the structure be such as to provide a background that would have harmony and unity, the result would be to provide an environment comparable to the restfulness of one's own home. This result not only caters to the mental and physical comfort of passengers but would have economic value to the owner.

Why should highly decorated period architecture be the attainment desired? True, many of the public rooms of hotels are too often treated in this manner, and it is probably an easily understood trend of thought to consider hotel and ship accommodations for guests and passengers serving, more or less, a somewhat similar purpose. This analogy may be open to question. On land the guest is not necessarily confined to the hotel for a time equivalent to the duration of a sea voyage. The hotel guest has the opportunity of release from an environment that may not be entirely satisfying. Whereas at sea there is no opportunity of escape, and if the environment from any cause is not pleasing, the unfortunate passenger is denied the opportunity of the thorough enjoyment of his voyage.

Another point in the economics of public rooms is the amount of hidden furring, bracing, etc., that has crept into or, perhaps better to say, remained in the construction, thereby increasing the cost and the fire hazard.

Furring behind linings as known at present, whether of treated or untreated wood, should be eliminated entirely. In any consideration of this subject it is not so difficult to understand how some of the practices developed as it is to account for their determined persistence.

All are familiar with the labyrinth of timber behind the side walls of some dining rooms where they have for some reason been framed away from the side of the vessel, also with the construction where frames and bulkhead stiffeners are furred and partially or entirely lined with boards to form backing for some type of composition board of lesser thickness than ordinary

Fig. 2. A stateroom of the United States Line Steamship "Manhattan," constructed with phenolic panels and treated wood post joists and trim.

bulkhead panels. A simple sill and top runner would have carried panels of appropriate thickness suitably jointed to take any desired face trim, thus obtaining the same result at much less expense and weight.

In dealing with such conditions in fire-resisting construction metal runners and joints are preferable, though treated wood is considered satisfactory. Either method is much less expensive than adhering to the more usual practices.

Elsewhere in the discussion of the fire hazard, a great many objections have been raised to suggestions for draft doors. The nature of the objections (viz., obstructing egress) again suggests consideration of this subject in the atmosphere created by the recent disasters and leading apparently to the anomaly of an objection to the provision of one of the most effective means of fire control in order to provide for the consequences of its omission.

These draft doors are swinging steel French doors of a standard make with clear wired glass practically their full depth. They cost relatively little and may be obtained with the Underwriters' label. They have been used by the writer for many years at stairway enclosures and elsewhere, and in actual service they suggest no danger of obstructing egress, creating confusion or any of the other objections. Rather, the reverse is the case. French doors for draft can also be made of treated wood to suit surroundings.

In considering the increased cost that might be involved in the cabin enclosure "B" bulkheading by the use of fire-resisting materials, it might be noted that the range in cost of fire-resisting panel material will probably be from about 35 cents to 55 cents per square foot, as compared with a probable range of cost of about 25 cents to 55 cents for untreated plywood panels.

It will, therefore, be apparent that by investigating thoroughly the suitability, advantages and disadvantages of the various materials available it would be quite possible to obtain suitable fire-resistant panels at little, if any, greater cost than many of the types so generally used.

In the matter of simplification of the methods of construction, it may be assumed with reasonable confidence that by making a fresh start in the consideration of this problem economies can be effected that will wipe out any adverse balance which might, in the light of existing practices, seem to be inescapable.

With only minor exceptions all vessels dealt with by the writer in the last decade have been fitted with fire-resisting "B" bulkheads in the accommodation constructed of metal and hard asbestos veneers or structural steel to suit conditions. Naturally, this could not have been accomplished without the coöperation of the owners and the assistance of the shipbuilders.

The Department of Health requirements with regard to rat proofing have in many cases been a source of great expense, and great economies will be effected by the use of some of the fire-resisting materials and methods of

construction previously suggested. In fact, the necessity for any additional rat proofing in the accommodation is practically eliminated.

It is believed that shipbuilders, from some of their experiences, will consider this a sizable item, running into figures that would probably cover a very high percentage of any cost differential occasioned by the use of fire-resisting materials.

There are difficulties in the development of satisfactory fire-retardant construction, but study and experiment with each succeeding vessel dealt with have brought conviction not only that they should but that they can be overcome without any increase of cost that cannot be balanced by corresponding economies.

**Tests.**

It is evident that, if fire-retardant materials are to be used for "B" enclosure and other bulkheads, it will be necessary to insure some uniform standard for the protection of the purchasers. For this purpose it will be necessary to develop satisfactory laboratory tests from samples taken from the actual materials to be used.

The production of fire-retardant lumber has been under consideration in this country since 1895. The results obtained in the production of this class of material have varied. The variations were due to the use of improper chemicals and it was not until 1926, a year of great demand for this material, that results consistent with the claims were obtained. Over a period of 26 years (i. e. 1895 to 1931) naturally a considerable amount of information was secured as to the suitability of chemicals to be used which would give the best results. For shipboard as well as land use it is essential that the means used be such that they will:

(a) Guarantee the permanency of the process.
(b) Not produce discoloration in the wood finishes, and
(c) Not corrode metal fastenings when used.

Fire-retardant lumber has already been developed to meet the requirements of tests prescribed by the City of New York, information regarding which can be readily obtained.

Fig. 3 shows the following test temperature curves:

(1)—"A-1" Curve. This test curve would presumably be the meaning of the 1500° for 60 minute test for statutory fire screen or "A-1" bulkheads. It is believed that the "X" curve of 1700° for 60 minutes would be a more satisfactory test, and where these bulkheads are usually insulated there should be no difficulty in withstanding this increase in temperature.

(2)—Test Temperature curve "A," 1500° for 30 minutes, is the suggested test for "A" bulkheads tentatively put forward in the N.F.P.A. regulations. It is believed that this curve should be eliminated and that the test be

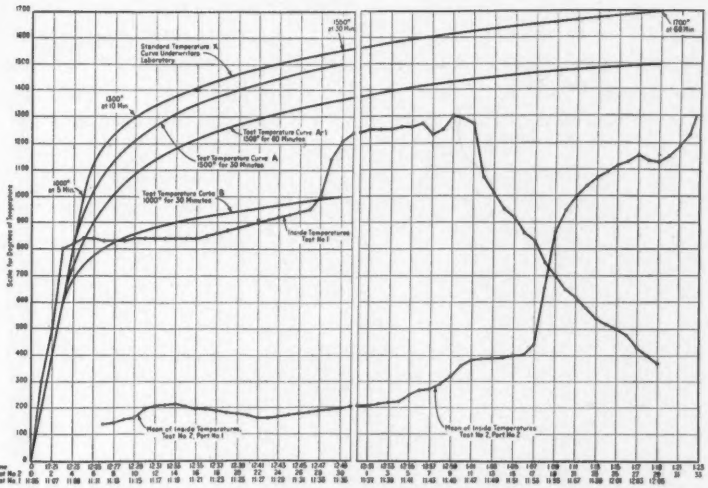

Standard Temperature Curve Underwriters Laboratory
1300° at 10 Min.
1000° at 5 Min.
Test Temperature Curve A-1 1500° for 60 Minutes
Test Temperature Curve A 1500° for 30 Minutes
Test Temperature Curve B 1000° for 30 Minutes
Inside Temperatures Test No 1
Mean of Inside Temperatures Test No 2, Port No 1
1500° at 30 Min.
1700° at 60 Min.
Mean of Inside Temperatures Test No 2, Port No 2
Scale for Degrees of Temperature
Time
Test No 2
Test No 1

**Fig. 3. Time temperature curves suggested for testing A1, A and B bulkheads compared with standard curve. Inside temperatures (mean) recorded in tests Nos. 1 and 2. All temperatures are Fahrenheit.**

1500° for 60 minutes, following the "A-1" curve. These bulkheads being of structural steel will withstand this test.

(3)—"B" Curve, 1000° for 30 minutes for "B" bulkheads tentatively suggested in the recommended regulations. It is believed in the light of further tests made that this curve should also be eliminated and that a more satisfactory test for these bulkheads would be the first 30 minutes of the "A-1" curve, where the maximum temperature reached at the 30 minute period would be about 1375°.

In other words, the suggested test temperature curves shown on Figure 3, four in number, would be replaced by two curves, that marked "X," standard temperature curve, Underwriters' Laboratories, 1700° for 60 minutes for "A-1" bulkheads. Test Temperature curve marked "A-1," 1500° for 60 minutes, would be used for "A" bulkheads. For "B" bulkheads, the first 30 minutes of the "A-1" curve would be used.

### Fire Tests—Cabin "B" Enclosures.

Two tests were made. The first was made on July 8, 1933, in which the combustible materials within the room consisted of loose short pieces of lumber, the weight of which was approximately equal to the amount of furniture normally installed in an average size stateroom. This was considered a quick fire test, which would approximate the method of testing class "B" materials in accordance with the requirements of the tentative N.F.P.A. rules.

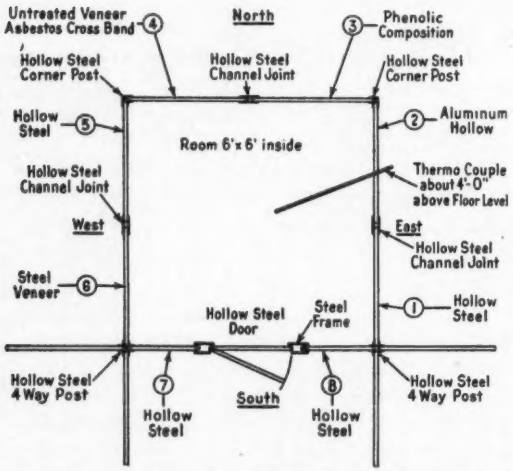



**Fig. 4. Diagram of room test No. 1, showing types of panels.**

The second test, on July 25, 1933, was for the same purpose as the preceding test with the results, however, obtained from a full-sized room furnished in a manner somewhat similar to staterooms on shipboard. This test was made in two parts. The first part was to determine what conditions would prevail under what might be considered the best conditions, as follows:

(a) With a slow starting fire,

(b) All drafts excluded, stateroom door closed, and with fan shut off at a point corresponding approximately to the time when an automatic alarm would register.

It might be stated that the conditions producing a slow fire would be those where there is no flimsy material lying around the room, leaving only the bed linen, wearing apparel and rugs for ignition.

The second part of this test was made under less favorable conditions, representing as nearly as possible the fact that a number of articles of wearing apparel of a flimsy material, such as lingerie, etc., might be lying around the room. To simulate this condition, several armfuls of loose excelsior and dry wood veneer were placed in the room and ignited, and

(a) The fan placed in operation, and

(b) All drafts excluded and the stateroom doors closed.

Even under these less favorable conditions it was evident that the fire was fairly well under control, as the maximum temperature reached was only 470 degrees at 1:07 P.M., or 17 minutes after the starting of part 2 of the test.

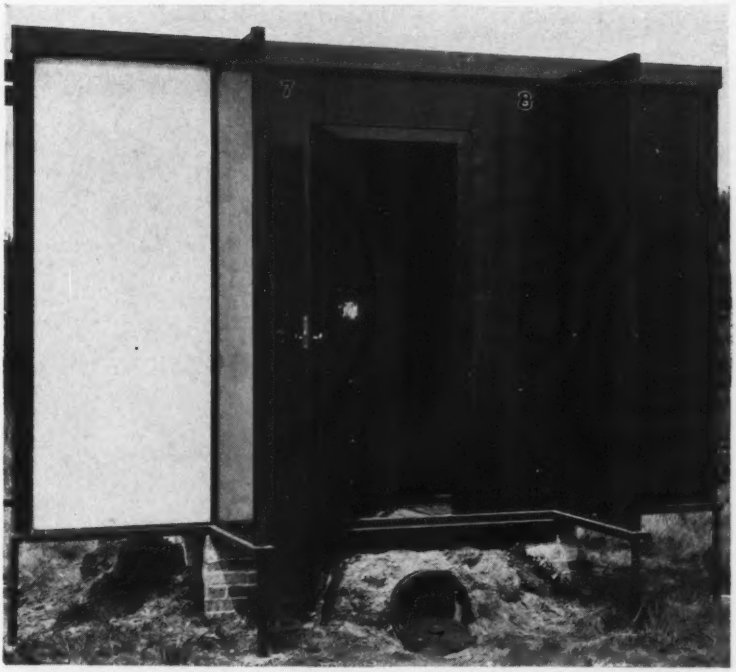


**Fig. 5. Test No. 1. South end of room before starting test. Pipe under floor was used to control the draft.**

The latter portion of this test (from 1:07 P.M. to 1:24 P.M.) was conducted with the south door open. The temperatures recorded during this period indicated a rapid combustion of the materials within the room and of the surrounding enclosure bulkheads, and the curves constructed from these temperature readings formed the basis for the tentative temperature curve for class "B" materials.

### Test No. 1—July 8, 1933.

For the purposes of this test a room was constructed about 6 feet by 6 feet inside dimensions by about 8 feet high (see Figs. 4 and 5).

To provide an adequate supply of air for combustion a 12-inch pipe was installed immediately under the door and carried to the underside of the floor grate. The control of the air passing through this pipe was regulated by a removable cover. The circulation of the air supplied was augmented or retarded by the opening and closing of the shutters over the openings in the roof. There were eight of these openings, each 8 inches by 4 inches.

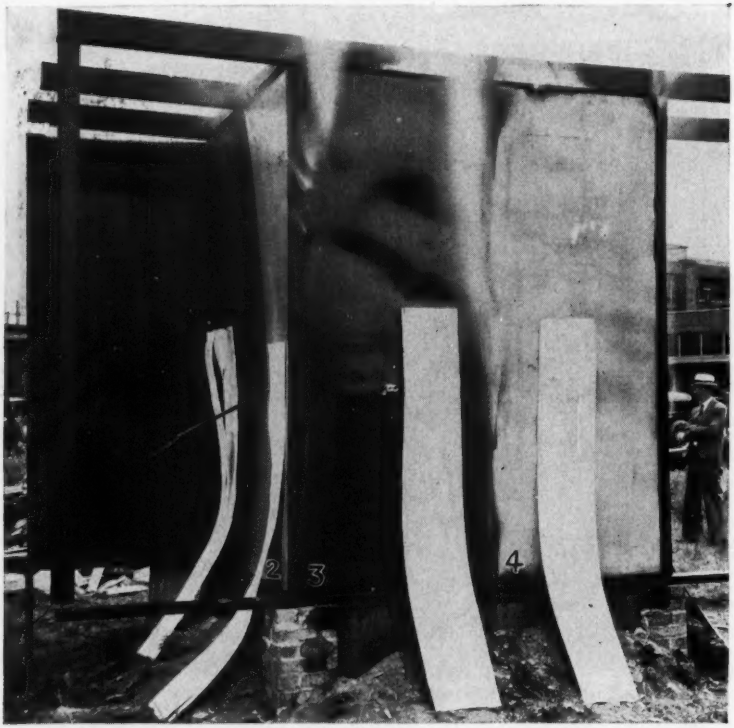



**Fig. 6. Test No. 1. North end, showing wood veneers lying against outer faces of panels. Note smoke escaping around panels.**

The space between the ground and bottom sills at the north and south ends was filled in with earth.

The combustible material used consisted of about 500 pounds of equal portions of hard and soft wood, spread over the entire area of the floor grate and well soaked with about two gallons of gasoline.

The fire was started at about 11:05 A.M. The door was open at this time, the air pipe cover off and the shutters over the vents in the roof in such positions that they did not restrict any portion of the openings.

Only one thermocouple was installed. That was in the northeast panel on the east side for recording the inside temperatures. No provision was made for recording temperatures on the outside faces of the panels.

The temperature within the room rose rapidly in the first four minutes, the couple recording about 820 degrees at 11:09 A.M. At this point the door was closed, followed by a partial closing of the vents in the roof at 11:11 A.M. Both of these operations retarded the combustion materially.

**Fig. 7. Test No. 1, showing condition of north and west walls after 50 minutes.**

There was no further rise in temperature until 11:21 A.M., or 16 minutes after starting the test. It should be noted that the air supply pipe under the door was throttled down at 11:15 A.M. leaving the cover about one quarter open. From 11:21 A.M. to 11:32 A.M. there was a gradual rise in temperature from 840 degrees to 950 degrees. At 11:37 A.M. the temperature had risen to 1250 degrees, and the maximum temperature of 1300 degrees was reached at 11:45 A.M., or 40 minutes after starting the test. From this point on to the conclusion of the test, which was reached at 12:05 P.M., there was a gradual drop in temperature, the final temperature recorded being 370 degrees. (For temperature curve see Fig. 3.)

Some pieces of dry veneer were laid against the outside of panels Nos. 1, 2, 3, 4, 5 and 8, and against the buttress panels on the southwest corner, the times were noted when these pieces of veneer started to burn. (See Table 1.) As no arrangements were made for recording temperatures on the outside faces of the panels, the estimates of outside temperatures were based on data obtained in Test No. 2.

Table 1 shows the results of this test.

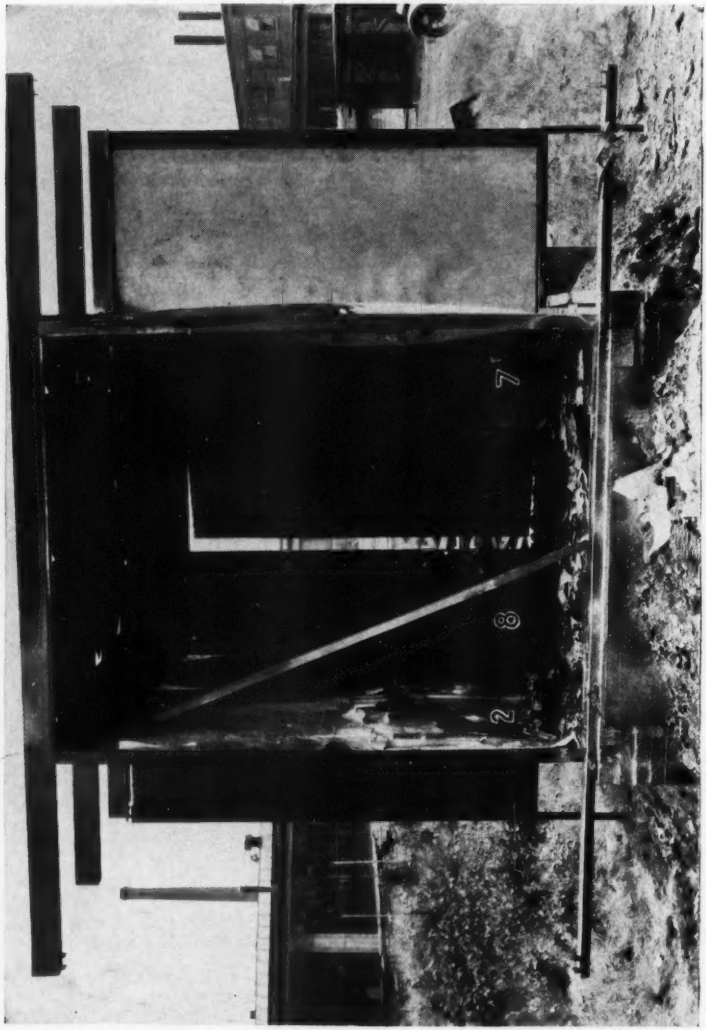



Fig. 8. Test No. 1. View of north end of room after conclusion of test. Panels Nos. 3 and 4 have been completely burned out. For data on other panels, see Table 1. Note that door is still in good condition.

TABLE 1.
Summary of Results, Test No. 1.
(Test extended for 60 min. Highest inside temperature 1300° F. at 40 min.)

| Panel No. (See Fig. 4) | Description of Panel | Probable Temperature Exterior Face of Panel | Time when veneer lying against outside started to burn | Action of Panel during Test |
|---|---|---|---|---|
| 1 | Steel, hollow, 22 gauge, stiffened | 450° | 34 min. | Panel buckled slightly but in place, all paint burned off. |
| 2 | Aluminum, hollow, .040" | 550° | 40 min. | Stood up well until burned through at 40 min. |
| 3 | Phenolic composition veneer. Core untreated plywood | — | — | Panel burning freely at 38 min. Entirely destroyed at end of test. |
| 4 | Untreated veneer. Cross bands sheet asbestos | — | — | No damage until 35 min. when flame came through joint. Entirely destroyed at end of test. |
| 5 | Steel, hollow, 22 gauge | 560° | 35 min. | Panel buckled slightly but in place. All paint burned off. |
| 6 | Steel veneer, 24 gauge. Untreated wood core. | — | — | No damage until 41 min. when flame came through joint. At end of test core consumed and veneers buckled. |
| 7 | Steel, hollow, 18 gauge, stiffened | — | — | Panel buckled slightly but in place. All paint burned off. |
| 8 | Steel, hollow, 22 gauge, stiffened | 450° | 28 min. | Panel buckled slightly but in place. All paint burned off. |

## Test No. 2—July 25, 1933.

For the purposes of this test a room was constructed about 9 feet wide by 12 feet long by 8 feet high (see Figs. 9 and 10).

The four walls of this room were made up of panels covering various types of Class "B" materials, as noted in Fig. 9 and Table 2.

The roof was one-quarter inch steel plate, covered with 1½ inch magnesite decking. The floor was one-quarter inch steel plate, perforated and laid on channel beams. The inside and outside faces of all panels and doors were given one coat of fire-resisting paint.

The room was furnished in a manner to simulate the appointments of a modern ship's stateroom, as follows:

Two steel spring cot beds with mattresses.
Two packing cases with mattresses laid on same to represent an additional bed.
One clothes locker, class "B" material, containing clothes.
Two packing cases filled with clothes and lingerie.
Two packing cases, empty, to represent furniture.
Two rugs on the floor.

It is estimated that the weight of the above combustible materials within the room was about 500 pounds.

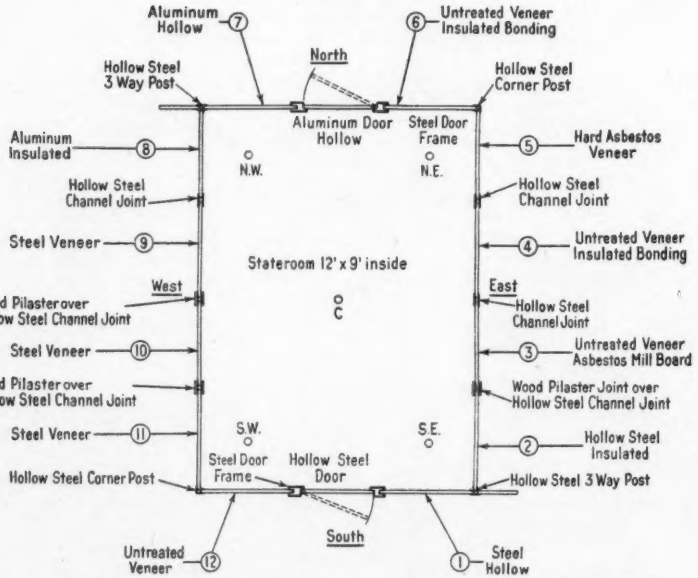



**Fig. 9. Diagram of room for test No. 2, showing types of panels used.**

To simulate further actual shipboard conditions, a ventilation duct was carried into the room, under panel No. 6 at the north end, the outer end of this duct being connected to a fan to furnish air to this room, and which was vented to the atmosphere through a 5-inch pipe at the south end of the room above panel No. 1.

Thermocouples were attached to each panel for recording the temperatures on the outer faces of each panel and were given the same numbers as the panels.

Thermocouples were installed within the room at five points for recording the temperatures within the room, as follows: one in each corner of the room, about 21 inches in from the panels, and about 4 feet above the floor level; one in the center of the room about 7 feet above the floor level.

The average of the temperature readings is shown in Fig. 3; maximum temperatures to which the individual panels were exposed, and the time required to reach 1000°, are recorded in Table No. 2.

The fire test was started at 12:19 P.M. Prior to starting the fire the tops of all mattresses were sprinkled with kerosene and a kerosene-soaked fabric was spread over all gaps. A match was then applied to the mattresses in the southwest corner of the room, the blower started and both doors closed.

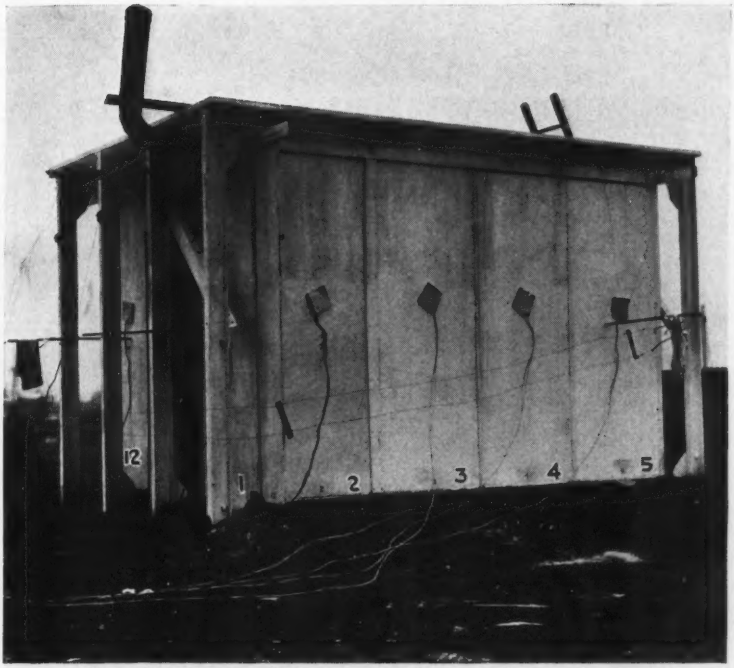



**Fig. 10. Test No. 2. View of east wall and south end of room taken at 1:08 P.M., 18 minutes after the start of Part 2. At this time inside temperatures were between 520° and 800° F.**

The blower was operated for a period of five minutes and then shut off, and while there was a considerable amount of smoke issuing from the discharge pipe at the south end of the room, it was evident that, since the operators at the recording instruments recorded little or no rise in temperature up to 12:25 P.M., or six minutes after starting the fire, to 12:30 P.M., 11 minutes after starting, some slight rise in temperature was noted but not of an amount that would indicate that the fire within the room was burning well, consequently the blower was again put in operation at 12:30 P.M. and continued for a period of four minutes. This had the effect of raising the temperature somewhat, but still less than was anticipated, so it was decided to open the south door to ascertain the progress of the fire. This was done and it was noted that the fire had not extended materially beyond the point of origin, and further that only a small flame was in evidence at this point.

At this point it was apparent that there was little chance of the fire developing with the draft conditions arranged for this test, i.e., with the door closed and the fan shut down, consequently it was not considered necessary

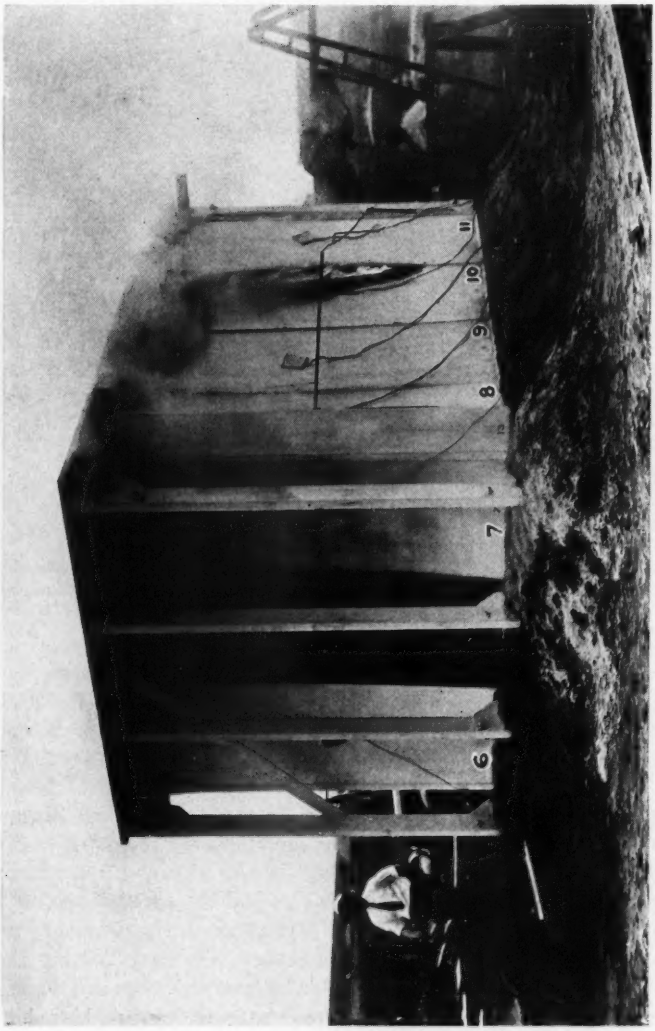



Fig. 11. Test No. 2. West wall and north end of room at 1:19 P.M., 29 minutes after start of Part 2 of this test. At this time the average inside temperature was approximately 1130° F.

Fig. 12. Test No. 2. North end and east wall of the room at 1:27 P.M., 37 minutes after start of Part 2 of this test. See Table 2 for description of condition of panels at this time.

Fig. 13. Test No. 2. East wall and north end of room at conclusion of test, 1:42 P.M., 52 minutes after start of Part 2 of this test.

TABLE 2.

**Summary of Results, Test No. 2, Part 2.**

(Test extended for 52 min.)

| Panel No. and Description (see Fig. 9) | Inside Maximum Temperature | Time 1000° reached | Temperature Outside of Panel | Action During Test |
|---|---|---|---|---|
| 1. Steel, hollow, 18 gauge, stiffened | 1430° at 32 min. | 22 min. | 560° at 33 min. | Panel buckled slightly but in place. Outside paint scorched. |
| 2. Steel, hollow, 18 gauge, stiffened. Insulated with asbestos cell board | 1430° at 32 min. | 22 min. | 748° at 33 min. | Panel buckled slightly at 18 min. Paint burned off upper part at 37 min. |
| 3. Veneer. 4 ply 1/20" poplar, ½" white pine, 2 ply asbestos mill board | 1400° at 33 min. | 21 min. | 160° at 30½ min. | No damage at 18 min. Fire through corner at 37 min. Entirely burned out at end of test. |
| 4. Veneer, mahogany balsa, insulated bonding | 1500° at 34 min. | 21 min. | 285° at 30½ min. | No damage at 18 min. Burning freely at 37 min. Entirely burned out at end of test. |
| 5. Hand asbestos veneer 5 ply white pine core | 1800° at 34 min. | 20½ min. | 175° at 30 min. | No damage except slight buckling at 37 min. Edges burning at 47 min. Entirely consumed at end of test. |
| 6. Veneer, insulated bonding, wood core | 1800° at 34 min. | 20½ min. | 172° at 31 min. | No damage except slight buckling at 37 min. Entirely consumed at end of test. |
| 7. Aluminum, hollow, .050 in., stiffened | 1440° at 34 min. | 26 min. | 511° at 25 min. | Burned spots noted at 15 min. Inner face melted, outer face intact but warped, paint burned off at 34 min. |
| 8. Aluminum, .050 in., stiffened, insulated with asbestos mill board | 1440° at 34 min. | 26 min. | 396° at 31½ min. | No damage except slight buckling and scorching at 35 min. Burned out, warped and melted at edge at end of test. |
| 9. Steel veneer, 27 gauge, on 5 ply wood core | 1400° at 33 min. | 20 min. | 230° at 32 min. | No damage except slight buckling and scorching at 29 min. Entire upper portion burning at 35 min. Core consumed but steel sheets still in place at end of test. |
| 10. Steel veneer, 24 gauge, on insulating core | 1300° at 33 min. | 20 min. | 372° at 32 min. | No damage except slight buckling at 27 min. Core burned out and steel badly warped at end of test. |
| 11. Steel veneer, 26 gauge on 7 ply wood core | 1340° at 33 min. | 19 min. | 202° at 32 min. | No damage except slight buckling at 27 min. Upper portion burning at 35 min. Entire panel collapsed at end of test. |
| 12. Wood veneer, on ¾" treated wood core | 1340° at 33 min. | 19 min. | 194° at 29 min. | No damage until a hole burned through at 25 min. Entirely consumed at end of test. |

to carry this part of the test further. This part of the test, which has been referred to as part 1 of Test No. 2, terminated at 12:50 P.M.

Part 2 of Test No. 2 was started at 12:50 P.M. Prior to the starting of the second part of the test, fuel had been added to the fire, consisting of two or three armfuls of loose excelsior and dry veneer wood which was placed on top of the mattress in the southwest corner. This was to represent a fire starting under less favorable conditions with a large amount of easily ignited material lying around the room. The door was left open to promote draft while the material was burning. As it was burning freely at 12:50 P.M., the door was closed, the fan shut off, and the second part of Test No. 2 was considered to have commenced at this point.

The inside temperatures recorded from 12:19 P.M. to 12:50 P.M., the first part of Test No. 2, as will be noted, did not rise above 275 degrees. This indicates what might be expected under the best conditions referred to above.

Part 2 of Test No. 2, which started at 12:50 P.M. and ended at 1:24 P.M., covers the less favorable conditions referred to above. The temperature rises up to 1:07 P.M. were somewhat small, notwithstanding the fact that fuel had been added to the fire, consequently the south door was opened at this point to promote combustion. This had the desired effect, resulting in a rapid rise of temperature.

The results of this test, together with information on the several panels, are summarized in Table 2. Figures 11, 12 and 13 show the extent of the burning.

## Conclusions.

These tests, while most helpful in confirming our beliefs in some of the essential features of any system of fire control, are, for a number of reasons, not conclusive, since obviously further tests are necessary with the door open for the entire period of testing. It is also considered necessary that tests hereafter should be made using one type of material and one system of construction throughout each "B" enclosure tested. There are, however, limits to what can be accomplished with one's personal resources together with solicited contributions of material by manufacturers and assistance of individual shipbuilders. Obviously the necessary tests to determine the general suitability of a number of materials and methods of construction should be continued in a more persistent manner.

# Whiskey Distilleries.

By Joseph G. Hubbell,
(Member N.F.P.A.)

Distilleries, along with breweries and yeast factories making grain vinegar, are primarily fermentation risks. Their initial activities are similar, as all produce a beer from malt and grain. The brewer produces a beer for sale. The yeast-vinegar works and the distiller produce a beer for distillation; the former to make a low wine from which is made vinegar, the latter to make spirits.

The distillery receives grain and malt, grinds and cooks the grain and grinds the malt, mixes them together with water to a mash in which the diastase of the malt converts the starch of the ground and cooked grain into fermentable sugars. This mash with added water is fermented and then is transferred entire to the still, where the alcohol is driven off. The spent grains from the still are drawn off as waste and fed to cattle or swine, or go to the dryer and are converted to feed. The distillate is barreled, aged and becomes whiskey.

Distilleries may make whiskey, cologne spirits, gin, sometimes do rectifying, and may have alcohol and denaturing departments. The great advance in the use of alcohol and related solvents favors diversification, and most large plants make a variety of products. Whiskey distilling is, however, a single product process. Brandy and rum are not whiskey distillery products, being derived from wine and molasses. The distinctions, "bourbon," "rye," "sour mash," etc., mean nothing in fire hazard. Bourbon whiskey is made from corn; rye whiskey from rye; sour mash is a method of treating the mash which influences the quality of the finished liquor.

In general, a whiskey distillery consists of a boiler house, engine room, grain elevator, mill, cooker and mashing department, fermenting house, distilling or column section, warehouses and a feed dryer. If cologne, neutral spirits or straight alcohol are made, a filtering (also called leaching) house is usually present.

The warehouse occupancies are usually barrel storage with a coopering department, cistern room, shipping warehouse, bonded warehouse and ordinary small service shops and storehouses common to all factories. There may be a denaturing department, a rectifying department, cattle sheds and hay barns, and tank storage of alcohol and fusel oil. Distillers commonly do not make malt, so malting will not be discussed in this article.

## Apparatus and Operations.

Distillers grind large quantities of grain—roughly ten bushels per barrel of whiskey output. No separation of ground materials is made, so the large

grinding capacity is not especially evident, as it would be in flour milling. The malt is usually ground in a special mill in the same section of the plant with the grain.

Cooking is usually done in boiler plate digesters with live steam. Mashing is done in large iron vats. Fermentation takes place in large open wooden vats, or in closed fermenters so carbon dioxide may be utilized. A special yeast culture room may be present and there is a small laboratory. The still or stills are of copper or iron, heated by steam coils. Fire heated stills have been relegated to moonshiners' use, as have worm condensers, though the latter may be used in secondary distillation. The column type of still and tubular condensers are practically standard.

A column is a tower of copper sections or rings of any desired diameter up to six or eight feet, and equivalent to several stories in height, rising through floor openings or standing in a tower structure with staging and stairway about it. The interior is a series of horizontal pans with lipped openings through the pans all the way up. In this device a combined distilling and condensing action goes on. The more volatile materials rise as vapor from the liquor which accumulates in the pans, and move up the column. The less volatile materials condense as the upper and colder part of the column is reached and flow down the column.

Columns may be operated as continuous stills with banks of steam coils in the bottom and a steady feed of fermented mash going in at the top. Any column still may be operated to produce any proof desired from cologne spirits down to low wine. For whiskey, "proof" is 100 or 50% alcohol; for cologne spirits, proof is 190 or 95% alcohol; for commercial alcohol, proof is 180 to 188. Absolute alcohol is 200 proof.

From the condensers, the distillate is brought down through pipes to sight glasses in a tail box in the distilling room so that operators can keep a check on the performance of the still and the quality of the distillate. From the tail box, the raw spirit goes to the cistern room, where the distiller mixes his distillates to the desired proof and the revenue officials measure and gauge the alcoholic content of the spirit and supervise the barreling, which for whiskey is always in charred barrels. Each barrel has marked upon it the quantity and proof of the contents. The barreled spirit goes to the shipping room. If the tax is paid, it is here delivered to the purchaser. Otherwise it goes to the bonded warehouse.

The fact that each package has an identity accounts for the type of construction of the bonded warehouse. It is built so that each package has its place and can be inspected or moved without disturbing any other package. The bonded warehouse is usually a brick or frame shelter built about a set of racks carrying the barrels tier upon tier, with pathways of boards every second tier. There are no floors; the story heights on the map are misleading,

as each story, so called, is the height of one double tier of barrels.

To remove odors from distillates which are to be sold as neutral spirits, the distillate may be put through bone black or charcoal in closed iron vessels, usually in rooms well heated with steam radiators. After this filtration the fiery pungency of the raw distillate is gone, the product lacks characteristic odor and taste other than alcohol and is called neutral spirits. These are used in blending and for some pharmaceutical and manufacturing purposes.

If gin is made, neutral spirit is placed in a still, juniper berries or coriander seed are added and the whole is distilled. The distilled spirit is flavored with the volatile elements of the berries or seeds used and is called gin. It requires little if any aging, so is likely to be a heavy share of the product, pending the aging of the new whiskey.

### Construction of Buildings.

Distillery buildings are of all types of construction. The older ones were principally of joisted brick or frame iron clad construction. Reinforced concrete and other types of incombustible or fire-resistive construction may be anticipated in new buildings, with a corresponding reduction in the fire hazard. Quite probably bonded warehouses will continue as they were before the prohibition era. In large plants there is general separation of departments. In small plants practically all manufacturing is in one building without fire separation of processes.

### Fire Hazards.

The grain elevator, the mill and the feed house are the principal fire hazards of whiskey distilleries. The grain elevator and mill arrangements should conform to N.F.P.A. regulations. They must be kept clean and a man should be on duty in each floor while operating. The man in charge should be a qualified miller and not someone picked out of the engine room staff. There is a severe mechanical hazard with danger of dust explosions or fire in both the mill and the elevator. These hazards are not comprehended by ordinary workers and the departments are not safe in such hands.

In general, bearings and machinery must be clean and well oiled, chokes in elevators or conveyors must be detected without delay, or fires will follow. No accumulation of dirt and dust is tolerable and the equipment must be tight to prevent all avoidable escape of dust. In milling, the grinding is rather coarse and usually on rolls, so the hazard here is less than when stock is ground fine or by attrition.

All grain mills should be protected by cleaning machines, air lift or good magnetic separators in the stock train immediately ahead of the mills, particularly if high speed grinding mills are used. Malt is extremely brittle and powdery and all standard malt mills have magnets ahead of the rolls, explosion vent doors on spring hinges in the mill casing and a revolving check valve in the base of the mill.

Cooking and mashing present no fire hazard. Cookers may burst from overloading, from seam corrosion or too much steam. Fermenting is non-hazardous—the gas emitted is carbon dioxide. The hazard of distilling is that of alcohol vapors, but as revenue officers are very exacting about anything which savors of laxity in controlling products of the still, there is likely to be but little escape of vapor. From the still to the shipping room through all the spirit handling departments, the revenue officers have lead sealed clamps on every joint, cover, valve and spigot of every piece of apparatus containing spirit vapors or spirit liquors.

One may detect a fusel smell in the column tower, but no more. As a precaution vapor proof lamps and outside control should be provided in the still and column room, the cistern room and in the alcohol and denaturing departments. Stills open for inspection, airing or repair present a hazard arising from vapors remaining in the apparatus. Open lights should never be brought open near manholes or ports, and forced ventilation with blast fans should precede repairs.

The feed drying department is usually pretty busy. The spent grains come from the stills wet, are pressed and then fed to dryers. These may be steam heated, but there is so much water to be removed, direct fire heated drum dryers are often used. Like most fire heated drum dryers, these are hazardous. If through oversight the dryer feed is not maintained, the temperature of the drum jumps up, the stock comes out on fire, is elevated to the top of the house, discharged to a wooden bin and about an hour later the place is on fire. The modern type of fire dryer is a relatively safe device. Steam dryers are much safer, although even with steam dryers temperatures are very high and fires may occur. The wet grains quickly sour and become offensive, so feed house conditions favor cheap help and frequently cheap arrangements. This department presents a high hazard. Values in it may approximate 10% of the total for a straight whiskey distillery.

If bone black filtering of spirits is done, there will be a furnace somewhere about the yard for revivifying bone black. If gin is made, the hazard is small because of the watchfulness of the revenue officers. In a straight whiskey distillery, there is normally no separation of fusel oil. In a general distillery, the fusels will be separated, as they now are valuable as solvents. They are propyl, butyl and amyl homologues of ethyl alcohol, very much less volatile, which come over as end products of the distillation. They have a powerful "fusel" smell but are not oils and, while volatile and combustible, need no special precautions in handling and storage beyond the usual for alcohol.

The warehouse departments, like the distilling, are in charge of revenue officers. All the handling of bulk fluid is in the cistern room in covered tanks, and piping and conditions do not favor any ill-considered action there, so the hazard is small. Commonly these departments work only through the middle

*David Caldwell.*

**This photograph was taken about 9 o'clock in the evening of November 17, 1911, during the burning of a large whiskey warehouse near Owensboro, Kentucky. The burning whiskey flowed down a ravine from the warehouse and on to the surface of the Ohio River, several hundred yards distant, where it continued to burn.**

of the day. The pace is very deliberate, space roomy and ventilation good. Branding of the barrels is done in the coopering department. Denaturing is like the cistern room operation but always a separate department and is done with small amounts of chemicals and with benzine, wood alcohol, etc. Denatured spirit is barreled in glue lined barrels; new regulations may permit bulk handling and tank storage. The hazard is of the same character and about the same degree as that of the cistern room. All operations in these departments are under close government supervision.

The bonded warehouse has no lights and usually no heat. Resort to quick aging may introduce heat in some bonded houses, but steam only would be used and the hazard is small. Bonded warehouses are accessible only on authority of the revenue officers and are their jurisdiction, not the distiller's. Fires in bonded warehouses are infrequent, but when they do occur, they are likely to be severe and to involve surrounding property if not fully detached. The racks collapse, the barrels burst and a flood of burning spirit is released. Bonded warehouses should stand on lower ground than other buildings or be diked so that a running fire will drain off without involving other property.

Where cattle or swine are fed distillery slops, the barns are usually large one-story frame buildings with the usual stable hazards. Hay sheds should be separate so as not to jeopardize the safety of the animals. The barns should not be exposed to the flow of burning spirits from warehouses.

If rectifying is done, the hazard is similar to that of a large wholesale liquor house with a rectifier's license. A rectifier is a blender. He operates under the control of revenue officers and if a distillery has a rectifying department, it is a wholly distinct activity from the distilling, always conducted in buildings at least 600 feet away from the distillery proper. Rectifying by a distiller is forbidden in some states. The hazard is mild as the fluids handled, while combustible, are not particularly volatile at ordinary temperature.

### Protection.

Distilleries are frequently located in small communities or outlying districts where public protection adequate to control fires is lacking. The ordinary working staff of a distillery is comparatively small, but water is always available and a general equipment of standpipes with 1½-inch hose and ½-inch nozzles is ideal for such properties. Every distillery should have standard first aid equipment.

Feed dryer houses should always be detached; they should have a good equipment of powerful hand hose and frequently do. Boiler houses can easily be cut off from the distillery and the grain elevator should be well separated from other buildings. Bonded warehouses have been previously discussed—the same precautions apply to alcohol storage in barrels or in tanks.

There is nothing about a distillery hazard not readily susceptible to control by automatic sprinklers except the dust explosion hazard of the elevator and milling departments and sprinklers are to be recommended as a satisfactory method of fire protection. This form of protection cannot, however, be recommended for bonded warehouses of any great height because of the lack of floors. In warehouses not exceeding two double tiers (total four barrels in all) sprinklers should do very well if well supplied at high pressure. Water acts in two ways on alcohol fires; it dilutes the spirits as well as controlling the fire. In higher warehouses, efficient action of sprinklers is problematical, as there is nothing to bank heat about sprinkler heads except the roof, and heads opening there might be too remote from the seat of the blaze. As a matter of fact, the rates of insurance in bonded warehouses unsprinklered are so low the owners would probably hesitate to spend the money for installation.

### Business Interruption by Fire.

Regardless of the nature of the output, whether whiskey, spirits, or alcohol, the process is a single train operation and a breakdown anywhere

stops production. In the present condition of the copper apparatus market, equipment could not be replaced in less than six months and possibly eight months to a year. Other single departments could be replaced in four to six months. The replacement of a large general distillery would be a matter of nine months to a year; of a small whiskey distillery, six months at the outside, assuming no delays on copper equipment.

## Fire Record of Distilleries.

The fire record files of the National Fire Protection Association contain reports on 92 distillery fires which have been recorded from 1904 to date. These include 78 fires in distilleries producing whiskey and alcohol from grain, and 14 fires in distilleries producing rum, brandy or alcohol from molasses or fruit juices. Except for the preliminary processes the fire hazards of the latter group are essentially the same as for whiskey distilleries.

This record by no means includes all distillery fires which have occurred during the twenty-seven-year period covered by the record, but the number is sufficient to indicate the potential fire hazards of the industry. Some idea of the relative frequency of distillery fires and aggregate loss may be obtained from the following data covering a 19-year pre-prohibition period ending December 1902, taken from the Chronicle Tables.

**Distillery Fires, 1883-1902.**

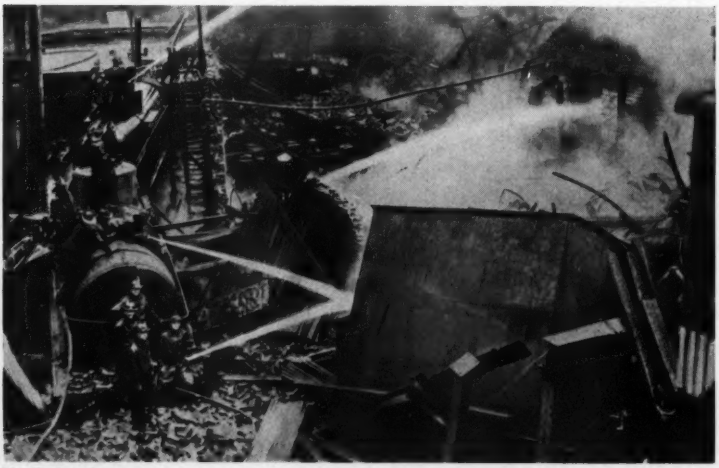
| | |
|---|---|
| Total Number of Fires | 336 |
| Average Number of Fires per Year | 18 |
| Aggregate Loss | $5,021,109 |
| Average Annual Loss | $264,270 |
| Average Loss per Fire | $15,000 |

The tables which follow show the point of origin of distillery fires, their causes, losses and record of sprinkler performance. These fires have been segregated into two groups, those due to special hazard causes and those due to common hazards. The special hazard fires have been further subdivided as to processes in so far as it was possible to do so.

The greatest number of fires occurred in operating and warehousing departments, these amounting to 66.3 per cent of the total number of fires. Of the fires in these departments the greatest number were in bonded warehouses, in the mill or grinding departments, or in connection with feed grinding. The apparent predominance of fires in bonded warehouses may perhaps be accounted for by the fact that such buildings outnumber distillery buildings more than two to one. Few distilleries have less than two bonded warehouses and many have from four to eight. Boiler rooms were the most frequent point of origin of fires in other than operating departments.

## Point of Origin of Distillery Fires.

| | | No. of Fires |
|---|---|---|
| **Operating and Warehousing** | | 61 |
| Bonded warehouse | 17 | |
| Feed drying | 8 | |
| Mill or grinding | 6 | |
| Still room | 5 | |
| Cistern or tank room | 5 | |
| Shipping and bottling room | 6 | |
| Rectifying room | 3 | |
| Alcohol storage (drums) | 3 | |
| Alcohol storage (tank) | 2 | |
| Yeast room | 2 | |
| Grain or malt drying | 2 | |
| Elevator | 1 | |
| Dust room | 1 | |
| **Other Sections** | | 19 |
| Boiler room | 6 | |
| Roof | 2 | |
| Outside walls (exposure) | 2 | |
| Cooper or carpenter shop | 2 | |
| Miscellaneous known locations | 7 | |
| No data as to location | | 12 |
| Total number of fires | | 92 |



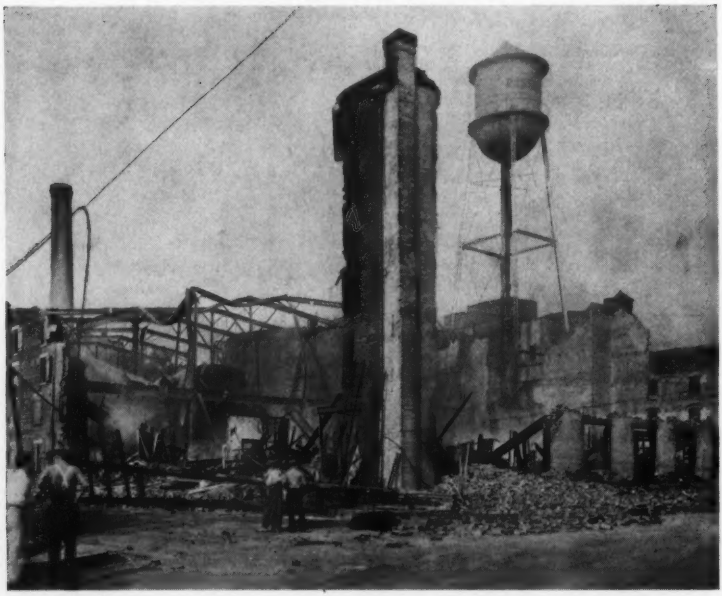
*Fire Engineering.*

**Firemen playing hose streams on ruins of distillery destroyed as the result of an explosion in the cistern room. Approximately 750,000 gallons of alcohol were destroyed in this fire.**

## Distillery Fire Causes.

| Special Hazard Causes | | No. of Fires | Per Cent of Known Causes |
|---|---|---|---|
| **Grain Storage and Handling** | | 13 | 23.2 |
| Foreign material in grinder | 3 | | |
| Heat from furnace ignited material in dry room | 2 | | |
| Friction in dryer fan or motor | 2 | | |
| Miscellaneous grain handling fires | 6 | | |
| **Distilling** | | 9 | 16.0 |
| Alcohol fumes ignited by open flame | 5 | | |
| Explosion in still or tank room—exact cause not known | 2 | | |
| Alcohol fumes ignited by electric spark | 2 | | |
| **Rectifying, Bottling, Shipping** | | 3 | 5.4 |
| Alcohol fumes ignited by broken light bulb | 2 | | |
| Sparks from branding barrels | 1 | | |
| **Warehousing** | | 6 | 10.8 |
| Alcohol fumes ignited by open flame | 2 | | |
| Alcohol fumes ignited by broken light bulb | 1 | | |
| Alcohol fumes ignited by defective extension cord | 1 | | |
| Alcohol fumes ignited by friction spark | 1 | | |
| Alcohol fumes ignited by spark from elevator motor | 1 | | |
| Total Special Hazard Causes | | 31 | 55.4 |
| **Common Causes** | | | |
| Electrical causes | 5 | | |
| Smoking—matches | 3 | | |
| Lightning | 3 | | |
| Spontaneous ignition—rubbish and sweepings | 2 | | |
| Kerosene lantern or stove | 2 | | |
| Miscellaneous known causes | 5 | | |
| Total Common Causes | | 20 | 35.7 |
| Incendiary | | 3 | 5.4 |
| Exposure | | 2 | 3.5 |
| Total Known Causes | | 56 | 100.0 |
| Unknown—suspicious | | 3 | |
| Unknown | | 33 | |
| Total Number of Fires | | 92 | |

Special hazards were responsible for 55.4 per cent of all fires of known origin. Of these special hazard fires 13, or 23.2 per cent, were chargeable to the handling of grain either in the mill or in the feed house; 9, or 16 per cent, occurred in the still room; 6, or 10.8 per cent, were due to the ignition of alcohol fumes or vapor in the bonded warehouse or alcohol storage tanks; and 3 occurred in the preparation of whiskey for shipment.



*Factory Mutuals.*

**A 62,000-gallon alcohol storage tank in this bonded warehouse at Lawrenceburg, Indiana, exploded from an undetermined cause. Ensuing explosions and fire almost completely destroyed the building and contents.**

## Losses in Distillery Fires.

| | No. of Fires | % | Aggregate Loss |
|---|---|---|---|
| Small (no exact figure given)..... | 20 | 21.7 | ..... |
| Less than $1000..... | 4 | 4.3 | $1,608 |
| $1001 to $10,000..... | 14 | 15.2 | 80,584 |
| $10,001 to $50,000..... | 21 | 22.8 | 486,429 |
| $50,001 to $100,000..... | 9 | 10.0 | 649,905 |
| $100,001 to $500,000..... | 13 | 14.0 | 3,435,220 |
| Over $500,000 ..... | 3 | 3.3 | 3,788,797 |
| Moderate (no exact figure given).. | 5 | 5.4 | |
| Large (no exact figure given)..... | 3 | 3.3 | |
| Total ..... | 92 | 100.0 | |

The loss record in distillery fires seems to indicate that, as a class, their location, almost without exception, in remote outskirts of large cities or in small communities where there is no adequate fire protection, has resulted in relatively high average losses. A further circumstance is that the product is stored on the premises to an extent as great as a year's total output or more. The burning of one of these warehouses is a sure total loss to its contents and, in property value, may easily equal the cost of building the whole distillery.

In but 41.2 per cent of the fires studied was the loss less than $10,000, and 30.6 per cent were reported as in excess of $50,000, or as "large."

### Sprinkler Fire Record.

Although comparatively few distilleries have been equipped with automatic sprinkler systems, there have been twenty-three fires recorded as having occurred in property protected by automatic sprinklers. Five of these originated in unsprinklered portions or were not of sufficient size to operate the sprinklers. The following table indicates the results of automatic sprinkler operation in this class of occupancy.

| | No. of Fires | % |
|---|---|---|
| Extinguished fire | 11 | 61.2 |
| Held fire in check | 4 | 22.2 |
| Total Satisfactory Operation | 15 | 83.4 |
| Unsatisfactory Operation | 3 | 16.6 |
| Total Sprinklered Fires | 18 | 100.0 |
| Sprinklers not a factor | 5 | |

The loss in those fires which were extinguished by the operation of automatic sprinklers was listed as "slight" in every instance. In the case of fires held in check, two were listed as slight, one involved a loss of $5000 and one a loss of $6900.

Two of the fires in which sprinkler operation was unsatisfactory involved losses of $64,987 and $500,000 respectively, and the third was listed as "large." The first mentioned occurred in a bonded warehouse and the failure of 400 sprinkler heads opened by the fire was due to the breaking of sprinkler piping by alcohol explosions in the early stages of the fire. The second fire occurred on the upper floor of a large warehouse occupied as a bonded warehouse for the storage of government whiskey. The watchman was not allowed to patrol this floor, which was also without heat, and the floor control valves to the sprinklers were shut off to prevent freezing of the system. The third fire was an exposure fire from a near-by refinery, which was too severe for the sprinkler system to handle.

# The Neunkirchen Gas Holder Explosion.

A gas holder explosion in Neunkirchen, Germany, on February 10, 1933, resulted in the death of sixty-eight persons, injury to several hundred, and severe property damage in the vicinity. An article describing this explosion appeared in the April, 1933 QUARTERLY (Vol. 26, No. 4, page 364). This article was prepared from reports received from Germany which were believed to be authentic, but which subsequent developments indicate were based on incomplete and hastily compiled information. It is now possible to provide a more accurate and complete account of the cause of the disaster. The following account has been prepared at the instance of the N.F.P.A. Committee on Gases by Chairman H. E. Newell from numerous technical reports.*

The Neunkirchen holder was of the M. A. N. waterless type of which many have been installed throughout the world during the last ten years. It was about 235 ft. high. In contrast to the telescopic holder, this container has a fixed steel shell, not cylindrical but polygonal in shape, built of thin steel plates, stiffened along their horizontal edges by flanges, which also serve for connecting them together. The shell is also stiffened by heavy vertical ribs and by circular girders extending around the outside of the shell about 50 feet apart. The gas is retained within the shell by a piston which floats upon the gas, moving up or down with the changing volume of the contents. The escape of gas between the piston and the shell is prevented by a flexible steel band, connected to the piston, extending around the inside of the holder shell and sealed in an annular trough filled with liquid tar, replenished by automatic pumps. The piston of the Neunkirchen holder was 160 feet in diameter and was strengthened by twenty-two radial trusses about 15 feet deep. The trusses were connected together by lateral bracing. Upon the piston trusses were mounted two rings of guide rollers, spaced vertically 15 feet apart, which travelled upon guide rails riveted to the inside of the shell and matching the outside vertical ribs. The rollers were adjusted to give a positive bearing upon the guide rails, thus preventing the tilting of the piston, though allowing it to move freely up or down.

Adjacent to the gas holder and elevated some 16 feet above the ground was a system of overhead gas piping, about 25 inches in diameter, which included the mains for delivering the fuel gas coming from the coke ovens and

*These include a report by the Gasholder Sub-Committee of The Institution of Gas Engineers, London; an article by Herman Leiber, of Hagen, published in Stahl and Eisen; an article by Counsellor Jacobi, president of the German Commission to investigate the causes of the accident; several articles from the *Gas Journal*, London, including one by Dr. Bunte, chief of the Karlsruhe Research Institute of the German Gas Association, and another by Prosecutor Staatsanwalt of Saarbrücken; also several articles from Das Gas und Wasserfach, including one by Dr. A. Mecklenbeck, Chief Engineer, Berlin Municipal Gas Works, and Chairman Gas Holder Committee, German Association of Gas and Water Engineers, and another by Dr. Nübling of Stuttgart.

used in the steel plant, piping pertaining to the near-by benzol recovery plant, and mains for delivering gas to neighboring towns. Interconnected with this piping was an overhead by-pass main, about 200 feet long, extending around the holder from the outlet indirectly to the inlet connection. Overhead piping adjacent to gas holders is an arrangement unusual in America.

Prior to the explosion, about 160 feet of the by-pass main had been taken down for alteration and the work of replacing it had been nearly completed. The pipe was in its elevated position, but still separated from the outlet pipe (through which gas was flowing) by a quickly removable blanking disc. At the other end the by-pass was to be connected to a gate valve on a branch of the inlet pipe, but through a settlement of the works pipe supports the flanges failed to match by about three quarters of an inch. Several different methods were resorted to by the workmen for bringing the flanges together. Meanwhile, gas had found its way (just how, no one knows) into the newly erected piping, forming an explosive gas-air mixture therein.

The workmen were untrained in gas operations and, not recognizing a hazard, undertook to burn away, with a cutting torch, the steel saddle supporting that end of the by-pass, thereby igniting the gas-air mixture within the piping and causing the explosion which wrecked the by-pass main, breaking off the upper part of the vertical pipe which extended downward to the outlet beneath the holder. This broken pipe pointed upwards, its upper end being about 8 feet above the ground. From its open end a flame was projected upward against the shell of the holder, for nearly its entire height. Eye witnesses report that the flame spread out to a width of 15 feet or more. It therefore seems probable that the holder shell was disrupted and gave way over a sufficient width to deprive the piston guide rollers of their support, thereby causing such a substantial dislocation of the piston that gas was projected into the space above, where an explosive gas-air mixture was quickly formed and ignited. The gas holder was completely wrecked.

The disaster was the climax of an extraordinary and unfortunate concurrence of several commonplace incidents, better management of which would undoubtedly have prevented the explosion.

An important lesson to be learned is that such operations should only be performed by men trained in the gas industry, working under close technical supervision. It should also be noted that at Neunkirchen the critical part of the work was undertaken at a late hour of the day and the men were undoubtedly affected by the natural impulse to hurry the job before darkness and quitting time arrived. The various official and unofficial investigators, including the Committee of the British Institution of Gas Engineers, seem to concur in the opinion that the disaster was the logical outcome of the improper supervision and handling of the work rather than the type of gas holder. None of the discussions so far appear to have developed any desirable improvements to be made in the design of the holder.

# Tank Truck Fire Record.

The importance of the automobile tank truck may be indicated by the statistical presentation of the transportation of gasoline for use in motor vehicles. In 1932 the registration of motor vehicles in the United States was reported as 24,276,000. For the operation of these vehicles approximately fifteen and one-half billion gallons of gasoline (or an average of 42,569,000 daily) were required, most of which was transported in tank trucks of one sort or another before reaching the ultimate consumer. To this must be added the transportation of fuel oil, kerosene and other petroleum products, most of which is also by tank truck at some stage of the journey from refinery to consumer. It is to the credit of the petroleum industry that the number of tank truck accidents and fires is small in proportion to the large quantities of flammable liquids it transports over the highways.

This subject is of particular interest at this time in view of the adoption by the National Fire Protection Association at its 1933 Annual Meeting of a suggested ordinance regulating the construction and operation of tank trucks, tank trailers and tank semi-trailers used for the transportation of flammable liquids, based upon the N.F.P.A. Good Practice Requirements for the Construction and Operation of Automobile Gasoline Tank Trucks adopted by the Association in 1929.

The descriptions of the individual fires in this record indicate that in the majority of cases the fire could have been avoided by observance of the published recommendations of the N.F.P.A. with respect to construction and equipment of trucks and operating procedure. A considerable number of the fires involved tank trucks operated by small dealers or jobbers who did not maintain the standard of equipment and operating procedure that has been characteristic of the larger oil companies that appreciate the importance of fire-safety measures. In some cases failure to comply with general requirements for handling of flammable liquids was the primary factor in the fire, rather than any fault with the truck itself.

Failure of the human element is shown by the record to be a major factor in these fires. Cases such as those of collision between tank truck and locomotive are so obvious that further comment is superfluous.

The tank trucks involved in the fires included in this record varied in capacity from a few hundred to several thousand gallons. The record shows no direct relation between the seriousness of a tank truck fire and the capacity of the tank, as some of the most serious losses occurred with trucks of relatively small capacity.

The files of the Department of Fire Record of the National Fire Protection Association contain reports of 111 automobile tank truck fires, 105 of

which involved the transportation and handling of gasoline. Of the remainder, three involved the transportation of fuel oil, two hot asphalt and one road oil. A previous record of automobile tank trucks was published in the QUARTERLY for January 1925, and was based on 35 fires which had been recorded up to that time. The present record is a statistical summary of all fires recorded from 1913 to date and includes those treated in the previous record. The summaries of typical fires, however, include only those fires which have occurred since the previous record.

The record is by no means complete and does not include many of the small fires which occur from time to time in connection with the operation and use of automobile tank trucks. Insurance inspection reports, petroleum company records and reports based on newspaper accounts which have been verified through the coöperation of N.F.P.A. members, are the source of data on the majority of the fires which make up this record.

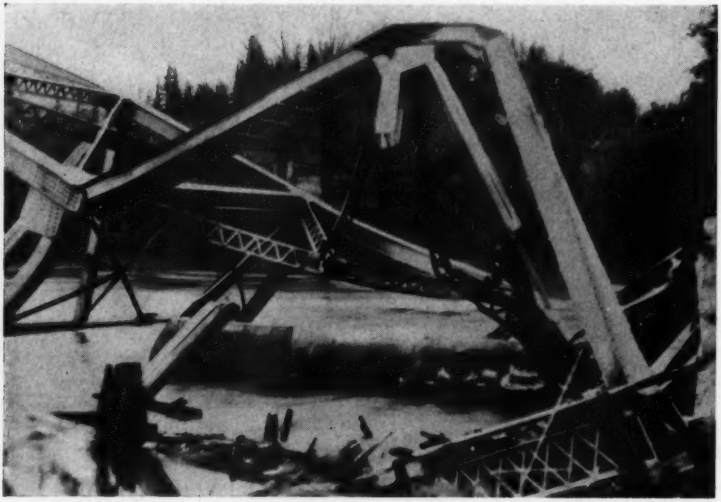
In view of the character of the original data, which include the larger and more important fires, but not a fair proportion of the smaller fires, this record may not be completely representative. The record does, however, include a sufficient number of fires to permit of generalizations as to the usual causes of tank truck and trailer fires and accidents and to indicate by specific example proper and adequate measures for their reduction.

In order to present the fire experience of tank truck operation in logical relation to the potential hazards of transportation and handling volatile flammable liquids, this fire record has been divided into three sections, Fires Occurring on the Highway, Fires Occurring During Loading Operations, and Fires Occurring in Connection with Unloading Operations.

## Fires Occurring on the Highway.

Thirty-nine fires, twenty-nine involving tank trucks and ten involving tank trucks and trailers, have been recorded which have occurred while loaded tank trucks and/or trailers were being operated on highways. Thirty-six of these fires involved tank trucks and/or trailers, used for the transportation of gasoline or gasoline and other petroleum products. Three involved tank trucks carrying fuel oil. In twenty instances the damage was limited to the tank truck and/or trailer, in fifteen instances the damage included not only the tank truck and/or trailer, but other property, and in four reports no definite data were available as to the extent of the damage.

Nineteen fires involved loss of life or injury. Twenty-nine persons lost their lives in these fires, fifteen of whom were drivers or helpers operating tank trucks and fourteen were other persons. Personal injuries were suffered by one employee and thirty-nine other persons. Of the injuries, twenty-five were occasioned in a single accident, being passengers on a train which struck a gasoline tank truck at a grade crossing in Edgewater Park, N. J., on July 28, 1917.



*International.*

**The heat generated by a burning gasoline tank truck was sufficient to cause the collapse of the steel girders of this bridge over the Snoqualmie River near Seattle, Wash., on Dec. 16, 1933. The driver jumped into the river and escaped with minor burns. Note ruins of truck in the river.**

The following table indicates the cause of tank truck fires which have occurred on the road. For the most part these are self-explanatory and are indicative of the hazards of highway transportation.

### Causes of Tank Truck Fires Occurring on the Highway.

| Cause | No. Fires |
|---|---|
| Railroad grade crossing accidents | 13 |
| Collisions with other vehicles | 9 |
| Tank truck and/or trailer skidded and overturned | 3 |
| Steering gear broke — tank truck crashed into pole | 1 |
| Driver asleep — tank truck crashed into tree | 1 |
| Trailer broke loose and punctured tank on truck — gasoline ignited by spark | 1 |
| Emergency fuel tank broke loose and gasoline ignited | 1 |
| Gasoline in sub-standard truck slopped over and ignited from exhaust | 1 |
| Gasoline leaking ignited by static spark | 1 |
| Gasoline line broke | 1 |
| Short circuit in wiring of tank truck motor | 1 |
| Back-fire of tank truck motor | 1 |
| Overheated brake bands | 1 |
| Total known causes | 35 |
| Cause unknown | 4 |
| Total fires | 39 |

## Analysis of Loss—Highway Fires.

| Loss | All Fires No. | All Fires Loss | Tank Truck Only No. | Tank Truck Only Loss | Tank Truck and Other Property No. | Tank Truck and Other Property Loss |
|---|---|---|---|---|---|---|
| Slight | 5 | ..... | 5 | ..... | .. | ..... |
| Less than $1000 | 2 | $700 | 2 | $700 | .. | ..... |
| $1001 to $10,000 | 6 | 43,421 | 4 | 24,580 | 2 | $18,841 |
| $10,001 to $50,000 | 4 | 85,289 | 3 | 50,289 | 1 | 35,000 |
| Considerable | 12 | ..... | 6 | ..... | 6 | ..... |
| Involved other property—loss not stated | 6 | ..... | .. | ..... | 6 | ..... |
| Total | 35* | | 20 | | 15 | |

*In addition to the above, there were four fires reported where no data were available regarding the property damaged or loss thereon.

## Typical Highway Fires.

OCTOBER 8, 1925. GLOUCESTER, MASS. A tank truck loaded with 500 gallons of gasoline collided with a railroad train at a private grade crossing and fire followed. The driver of the truck was thrown from his seat by the crash and before help could reach him was enveloped by flames from the burning gasoline. He died shortly after reaching the hospital. The truck was tossed into a small bridge tender's shanty near by and the bridge tender was trapped inside. He was badly burned before he could escape. Passengers on the train were uninjured. The truck was destroyed. (H-22519.)

FEBRUARY 19, 1926. TAMPA, FLA. A small sedan collided with a gasoline tank truck and trailer with sufficient force to overturn the trailer and cause it to break loose from the truck. The truck careened down the street and collided with a parked automobile, resulting in the opening up of the seams of the tank. Gasoline was ignited from sparks generated by the impact of the collision or from contact with the hot exhaust pipe of the truck. The burning gasoline flowed down the street, setting fire to several buildings and an automobile, and threatening the entire neighborhood. The fire department used hose streams for an hour and a half before the fire was extinguished. (H-23273.)

DECEMBER 19, 1926. OAKLAND, CALIF. When an automobile collided with the rear of a tank truck containing 3375 gallons of gasoline, the discharge valve of the tank was broken off. Gasoline flowed from the open end of the delivery pipe, and in spite of the partially successful efforts of the driver to check the flow by stuffing rags into the pipe, a large area of pavement was covered with gasoline. Presently another automobile entered the area, skidded on the gasoline-wet pavement and also crashed into the rear of the tank truck. This second crash broke off the remainder of the gasoline discharge pipe and the liquid poured from the truck, covering the streets for several blocks.

The fire department was called and endeavored to flush the gasoline into the sewers with hose streams. Before this could be accomplished, however, some small boys threw a lighted match into the gasoline, and almost instantly

*Fireman's Fund Record.*

**When a gravel truck crashed into a tank truck in a traffic jammed Dallas, Texas, street, escaping gasoline ignited.**

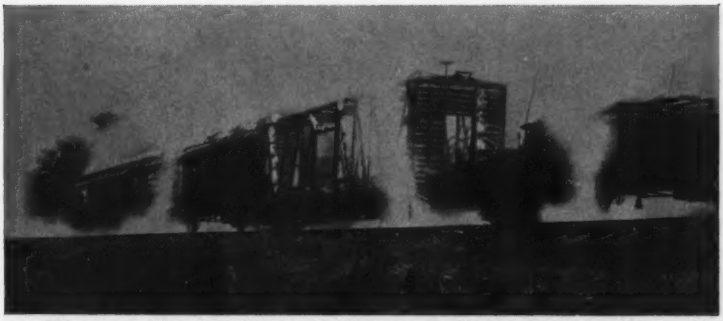
the streets for a space of nine blocks were a mass of flames. So intense was the heat that three houses caught fire, although set back a considerable distance from the curb, and the ignition of a number of other houses was prevented only by the efforts of the fire department. Three firemen and a policeman were burned in rescuing spectators and motorists from the path of the flames. (H-24178.)

MARCH 24, 1927. DALLAS, TEXAS. A gasoline tank truck proceeding along a street in the principal business district was obliged to slow up for traffic and had practically come to a stop, when a loaded gravel truck immediately behind, crashed into it. The collision smashed the can box, or small service compartment at the rear of the tank truck, and ripped off the discharge valves of the tank. There was no emergency control on the discharge pipes and gasoline flowed freely into the street and ran in little rivers along the gutters.

Fire did not occur until the gravel truck backed away, when a spark, either from the friction of metal parts or from the hot exhaust pipe on the tank truck, caused the gasoline to ignite. An intense fire immediately ensued, the flames rising above the roofs of eight and ten-story buildings near by. Six automobiles parked at the curb were destroyed and two others badly damaged. Both the tank truck and the gravel truck were badly damaged. Adjoining buildings were blackened by the smoke, windows were broken by the intense heat and mercantile stocks were damaged. Trolley, electric light and telephone wires were burned and fell into the street, adding to the confusion and damage. The loss was estimated by fire department officials to be $9841. (H-24879.)

AUGUST 13, 1927. CRIDERSVILLE, OHIO. An unusual accident occurred when a train, reported to have been traveling at a rate of fifty-five miles an hour, crashed into a gasoline tank truck which had stalled on a crossing. The truck driver jumped clear of the collision, but was showered with blazing gasoline. He died later as a result of his burns.

The burning gasoline enveloped the train. The engineer and fireman were burned to death in the cab. The train went on, speed unchecked, the forward cars all ablaze, until a trainman set the brakes, bringing the train to



**When a gasoline tank truck was hit by a speeding train at a grade crossing near Cridersville, Ohio, blazing gasoline enveloped the train. The above view shows the burning train after it had been brought to a stop. The engineer and fireman were burned to death in their cab, and an express messenger was trapped in the baggage car. The truck driver was also burned to death.**

a stop half a mile beyond the crossing. The passengers escaped before the fire spread to the rear cars. Two hours later the body of an express messenger was found, burned to death, in the baggage car where he had been trapped, making the total toll of life four. The heat from the fire was sufficient to warp the rails, which had to be replaced. (H-24833.)

FEBRUARY 3, 1929. PITTSBURGH, PA. A tank truck containing 1500 gallons of gasoline overturned and caught fire while passing through the business district of the city, resulting in considerable property damage and the loss of two lives. The accident occurred when the truck, traveling at high speed, struck a traffic light pedestal in the middle of the street intersection, while the driver was attempting to make a turn. The truck then struck an iron sewer cover, jumped the curb and continued along the sidewalk for approximately a hundred feet before returning to the street, where it overturned. The driver and his helper were thrown from the truck, the contents of which were immediately ignited. The burning gasoline spread over a large section of the street, enveloping the two men, who were burned to death.

When the first firemen arrived the tank truck and two near-by brick buildings were in flames, and blazing gasoline was flowing downgrade toward the river. Some of the gasoline entered the sewer, igniting sewer gas and causing explosions which blew manhole covers into the air. The fire was brought under control by the use of hose streams.

The gasoline storage tank on the truck involved in the fire was constructed with five compartments. The forward two compartments ruptured and their contents, amounting to about 700 gallons, were destroyed. The contents of the three remaining tanks did not ignite in spite of the intense heat. The tank truck was badly damaged and the loss to the buildings involved was estimated at $15,500. (H-27812.)

**Traveling at a high rate of speed through Pittsburgh streets, this tank truck failed to make a turn, tipped over, and burst into flames. The truck was badly damaged. The driver and his helper were burned to death and adjacent property was considerably damaged. In spite of the intensity of the fire, but two of the compartments of the truck were involved.**

FEBRUARY 9, 1929. BOSTON, MASS. A tank truck carrying 1200 gallons of gasoline was proceeding along a busy street during the evening rush hours, when the steering knuckle broke and the truck swerved to the side of the street out of control. It struck a pole supporting trolley car wires and then skidded into another pole which carried light, power and telephone lines. Both poles crashed to the ground and it is thought that a live wire brought down by the falling poles ignited gasoline flowing from the wrecked truck.

The driver of the truck escaped with his life by leaping from his seat just as the gasoline ignited. The burning gasoline flowed down a slight grade to a bridge over a small stream, igniting the wooden planking on the bridge and burning on the surface of the water. The fire department fought the fire with foam and with water lines. A trolley car, which was stalled in the fire area, was moved before it caught fire. The passengers escaped without serious injury. The truck was badly damaged. (H-27158.)

AUGUST 17, 1929. RED GATES, MD. A gasoline tank truck caught fire when its fuel line broke. Flames quickly enveloped the truck, causing the driver to lose control, and the truck plunged into a steam roller which was working on the road. The driver was severely injured when he was thrown through the windshield by the impact and his hair was singed off by the fire. The fire burned off the top of the steam roller and ignited the tarred road and

near-by underbrush before firemen arrived. The fire department extinguished the fire in the truck by use of chemicals. (H-32445.)

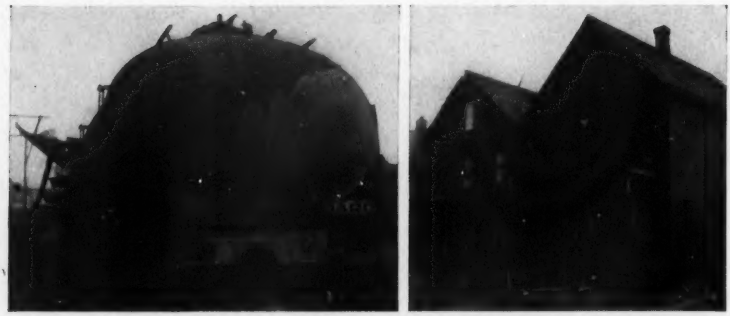
OCTOBER, 1929. SAN DIEGO, CALIF. A tank truck carrying 500 gallons of aviation gasoline took fire between Marine Corps hangars and the Naval Air Station as a result of a back-fire in the carburetor. The force of the explosion was sufficient to carry away the gasoline line at the carburetor; with this flow of gasoline the fire assumed dangerous proportions. Soda-acid, foam and carbon tetrachloride extinguishers and sand were used in an unsuccessful attempt to extinguish the fire in the flowing gasoline. Two carbon dioxide extinguishers were then used, which promptly extinguished the fire. (H-29899.)

DECEMBER 9, 1929. FAMOSA, CALIF. A tank truck and trailer carrying a total of 2500 gallons of gasoline stalled at a railroad crossing and was struck by a speeding train. The train was showered with flaming gasoline and fire spread through the cars, consuming all combustible material. The driver of the truck escaped before the crash, but the engineer, fireman and mail clerk on the train were fatally burned. Fortunately the engineer was able to stop the train before he jumped from the cab. The forty passengers on the train escaped uninjured. (H-29283.)

FEBRUARY 25, 1930. MEDFORD, MASS. While passing through this city a tank truck containing approximately 2000 gallons of light fuel oil caught fire from an overheated brake band on a rear wheel. The fire department was summoned and directed a hose stream on the tank to keep it cool and prevent an explosion. (H-33970.)

MARCH 20, 1930. WALTHAM, MASS. A fire occurred in the cab of a fuel oil truck as it was proceeding along a city street. Before the driver could bring the truck to a stop his clothing was ablaze. After extinguishing his burning clothing he put out the fire in the truck, using first aid equipment carried on the truck. Fire did not reach the oil tank. The damage to the truck was slight. (H-32115.)

JANUARY 20, 1931. ORANGE, N. J. A tank truck and trailer, carrying a total of 4900 gallons of gasoline from a refinery to a distributing station, was crossing a deep gutter when the draw bar of the trailer broke near the truck. The safety chains held the trailer, but did not prevent it from bumping the truck and puncturing the rear compartment. Gasoline poured out through the opening and ignited, either by means of a spark due to the impact, the scraping of the tongue on the pavement, or from the exhaust of the motor. The fact that the safety chains held the trailer prevented the operation of the emergency air brakes and the driver was unaware of the break until he noticed that the trailer did not guide properly. He steered the truck to the curb and as he brought it to a stop the truck burst into flames.



**Two views showing results of tank truck accident at Orange, N. J. Left: Rear view of tank truck, showing punctured tank. Right: These two houses were ignited by the burning gasoline in the street and damaged to the extent of about $6000.**

The burning gasoline ran down the gutter for a distance of about 500 feet, but was stopped at intervals by dams made of sand secured from a filling station near by. This prevented the blazing gasoline from entering the catch basin. A westerly wind blew the flames from the burning tank truck toward two frame dwellings, which caught fire, and considerable damage was done before it could be extinguished.

The fire was fought with hose streams from hydrants and pumpers for half an hour until a foam generator and powder could be obtained from an adjoining town. As soon as the generator was put into operation the flaming gasoline was quickly smothered. The pressure release vents provided on each compartment of the truck and trailer functioned properly and prevented an explosion.

The loss to the truck and contents was about $3000, and to the buildings about $6000. The driver of the truck was slightly burned. There were approximately 1500 gallons of gasoline destroyed. (H-31392.)

SEPTEMBER 9, 1931. DELANO, CALIF. A filling station employee who was standing in front of his station observed the approach of a large gasoline tank truck and trailer and noted that the tires of the truck were aflame. He ran out into the street and waved to the driver who, at that time, was unaware that anything was wrong. The truck was driven about fifty feet beyond the station, where it burned until extinguished by the fire department.

The primary cause of the fire was the failure of the supports of an emergency fuel tank, which permitted the tank to drop down at the forward end. Upon striking the pavement, the tank opened up and escaping gasoline saturated the tires. Ignition may have come from sparks struck by the tank, the static chains or from the exhaust muffler.

The tank truck had two domes and the trailer had one dome, each

*International.*

**The trailer of this tank truck overturned and took fire when the truck skidded on the wet pavement of a Los Angeles suburb. Tank and trailer together contained 6205 gallons of gasoline.**

equipped with pressure and relief fittings plus two fusible plugs at each dome. During the fire five of the six fusible plugs let go and flames extended upward for over thirty feet. Paint on the service station was scorched and a near-by cottage caught fire. The fire department first extinguished the fire on the truck cab and tires and then snuffed out the vent fires, using hose streams. Tank gauges after the fire showed a loss of 823 gallons. (H-35277.)

OCTOBER 17, 1931. LOS ANGELES COUNTY, CALIF. Traveling along the boulevard between Los Angeles and Long Beach, a tank truck and trailer containing 6205 gallons of gasoline skidded on a wet pavement. The driver lost

control of the truck and the trailer overturned. A spark, probably due to the crash, ignited the gasoline which poured from the wrecked trailer. The truck and trailer were a total loss, and heat and flames severely damaged the telephone poles and pavement in the vicinity. Fortunately the accident occurred in the open country, where no buildings were exposed. (H-34528.)

NOVEMBER 28, 1931. BOSTON, MASS. Four hundred gallons of fuel oil and a similar amount of gasoline were endangered when the driver of a small gasoline tank truck attempted to tow a fuel oil truck up a grade in a narrow street and the gasoline tank truck caught fire. The fire, which occurred as a result of a short circuit in the wiring of the truck, was extinguished without involving the gasoline tank. The loss was estimated at $50. (H-34997.)

JULY 20, 1932. BRIMFIELD, MASS. A tank truck and trailer loaded with 5000 gallons of gasoline were destroyed in a fire on the Palmer-Brimfield road. The truck was traveling down a long grade, when flames came through the floor boards. The driver and his helper jumped from the truck which, driverless, plunged down an embankment. The trailer overturned in the road. Three severe explosions occurred when flames reached the tank compartments and their contents were ignited. (H-35738.)

AUGUST 29, 1932. EAST PATERSON, N. J. A trailer attached to a tank truck was struck by another truck at a street intersection and overturned. The driver of each vehicle believed he was proceeding on a green traffic light. The tank truck and trailer each contained 2700 gallons of gasoline, but only the trailer was involved in the fire.

Immediately after overturning, gasoline flowed from the filling openings of the trailer tank and was ignited either by means of a spark caused by the scraping of the trailer on the pavement, or from the motor exhaust. Burning gasoline ran down the gutter to a small brook near by. Heat from the fire vaporized the gasoline remaining in the trailer tank and the vapor escaping through the safety valves ignited and added to the intensity of the fire. The proper operation of the safety valves prevented any explosion.

A near-by dwelling, barn, and a shed were ignited by the heat. Firemen used three hose streams to extinguish the building fires and at great personal risk uncoupled the tank truck, which had not caught fire, and moved it and the other truck involved in the accident to a safe distance. No foam equipment being available, the fire in the trailer was allowed to burn out and the trailer was destroyed. (H-35547.)

DECEMBER 2, 1932. BRIDGEWATER, MASS. A small tank truck of substandard construction, carrying 315 gallons of gasoline, caught fire while traveling at a high rate of speed. The tank of this truck was divided into three compartments and the cover to the opening in the rear compartment had been lost. This had been replaced by a misfit substitute cover, which is known to have fallen off shortly before the fire. Witnesses first observed fire under the

*Pacific Coast Fire Chief.*

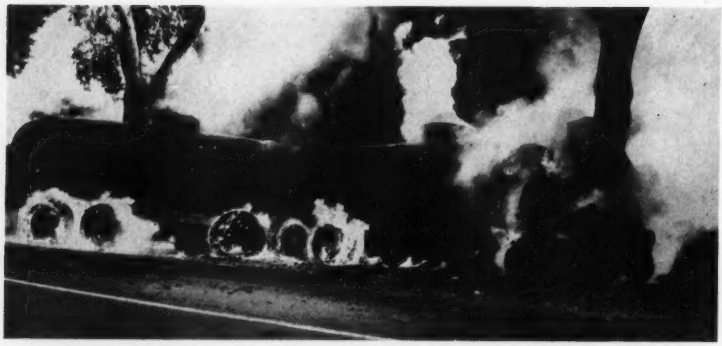
**Traveling along a wet highway, a heavily laden tank truck and trailer swerved to avoid a skidding sedan and crashed into a small ranch house. Burning gasoline enveloped the building, in which the family was gathered about the breakfast table. All escaped except a baby, whose crib in an adjoining room was drenched with gasoline when the crash occurred.**

truck and it seems probable that gasoline, spilled from the rear compartment after the cover was lost, was ignited by the hot exhaust pipe.

Apparently upon discovering the fire the driver lost control of the truck, which swerved to the left side of the road, tipped over, dragged along about two hundred feet, and burst into flames. The driver was caught behind the wheel and was burned to death. A passenger in the truck was thrown out and burned to death in the road. During the fire the seams of all three compartments gave way, due to the severe heat. There was no explosion. (H-36050.)

APRIL 20, 1933. MOARK, ARK. A railroad train, running at approximately sixty miles an hour, struck a gasoline tank truck at a grade crossing. Flaming gasoline from the 1500-gallon load in the truck was sprayed over the locomotive, severely burning the engineer before he could bring the train to a stop three-quarters of a mile away. The driver of the tank truck was instantly killed and his body was burned. The fireman on the train was killed when he jumped from the flaming cab. Two men working near the place of the accident were also burned by blazing gasoline. All-steel equipment prevented serious damage to the cars of the train. (H-36677.)

AUGUST 24, 1933. SAN JOSE, CALIF. A gasoline tank truck and trailer were destroyed in a fire which occurred when the truck struck a tree. Several explosions occurred while the 7500 gallons of gasoline in the tanks were being consumed. The crash evidently resulted when the driver fell asleep at the wheel. He was cremated in the cab of the truck. Firemen were unable to extinguish the fire and the blaze continued until the gasoline was consumed. (H-37047.)



*Acme.*

**When the driver of this gasoline tank truck and trailer fell asleep at the wheel the truck crashed into a tree on the highway near San Jose, Cal. The driver was burned to death and the 7500 gallons of gasoline which the truck and trailer contained was entirely consumed by the fire.**

## Fires Occurring During Loading Operations.

The greatest number of tank truck fires recorded in the N.F.P.A. fire record files occurred in connection with loading operations on the premises of oil companies. Forty-eight such fires are included in the record. In seventeen of these fires the tank truck alone suffered damage, in twenty-seven fires the tank truck and distributing station were involved, and three fires caused damage to the tank truck, distributing station and adjacent property. There was one fire on which no information was available as to the extent of damage. All of the tank trucks involved were being used for the transportation of gasoline, with the exception of one, which was being loaded with road oil.

The loss of life and injuries recorded for this group of fires was considerably less than for highway fires and fires occurring in conjunction with unloading operations. This may perhaps be accounted for by the fact that most of the fires in the group occurred on the premises of oil companies, where good practice requirements and safety precautions are generally enforced. Ten fires involved loss of life or injury, with a total of five employees and two others killed and five employees injured.

### Analysis of Loss—Loading Operation Fires.

| Loss | All Fires | | Tank Truck Only | | Tank Truck and Other Property | |
|---|---|---|---|---|---|---|
| | No. | Loss | No. | Loss | No. | Loss |
| Less than $1000..... | 3 | $238 | 3 | $238 | .. | ..... |
| $1000 to $10,000..... | 11 | 54,291 | 7 | 34,500 | 4 | $19,791 |
| $10,001 to $50,000... | 10 | 294,204 | 2 | 27,000 | 8 | 267,204 |
| Over $50,000 ..... | 3 | 273,262 | .. | ..... | 3 | 273,262 |
| Large (no figures) ... | 13 | ..... | .. | ..... | 13 | ..... |
| Considerable ..... | 8 | ..... | 5 | ..... | 3 | ..... |
| Total..... | 48 | | 17 | | 31 | |

The causes of fires incident to loading operations are covered in detail in the table which follows.

### Causes of Tank Truck Fires—Loading Operations.

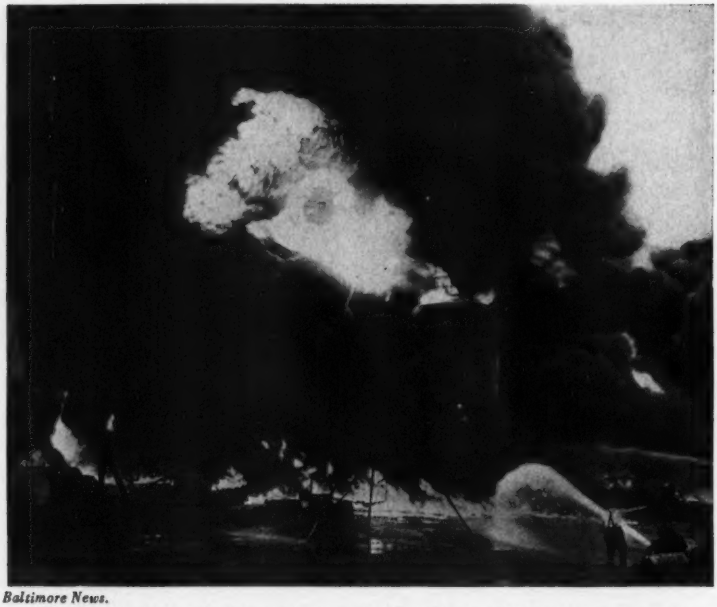
| Cause | No. Fires |
|---|---|
| Static electricity while filling tank truck | 12 |
| Gasoline vapor ignited by back-fire | 6 |
| Gasoline spilled and ignited by hot exhaust pipe | 6 |
| Gasoline spilled and ignited by back-fire | 3 |
| Supply pipe to tank truck broken and gasoline ignited | 3 |
| Ignition from hot exhaust pipe (1), metallic spark (1), adjacent rubbish fire (1) | |
| Miscellaneous known causes | 12 |
| Gasoline vapor ignited by lighted lantern | 1 |
| Gasoline vapor ignited by metallic spark | 1 |
| Gasoline vapor ignited by defective light socket | 1 |
| Gasoline vapor ignited by back-fire of gasoline engine driving pump | 1 |
| Gasoline vapor ignited by spark from electric switch | 1 |
| Gasoline overflowed and ignited by spark from truck motor | 1 |
| Short-circuit of wiring of truck motor | 1 |
| Static electricity, back-fire, or short circuit | 2 |
| Exposure from near-by fire | 3 |
| Total known causes | 42 |
| Cause unknown | 6 |
| Total fires | 48 |

### Typical Fires in Connection with Loading Operations.

JUNE 11, 1925. NEW ORLEANS, LA. This fire occurred while a tank truck was being loaded with gasoline at a bulk distributing station. One compartment of the truck had been filled, and when the filling spout was moved to another compartment, some gasoline spilled over the sides of the truck and ignited from the hot exhaust pipe. The fire was extinguished by company employees with a loss of $50. One employee was slightly burned. (H-31792.)

JULY 8, 1925. CHATTANOOGA, TENN. While a tank was being loaded with gasoline at a distributing station the driver started the engine to adjust the timer. While tinkering with the engine a back-fire occurred, probably due to the driver having "shorted" the timer long enough to fill the muffler with gasoline vapor. A long flame issued from the exhaust pipe and ignited gasoline drippings on the ground at the rear of the truck and under the wooden loading platform. The platform and ground beneath were thoroughly saturated with oil and the flames spread rapidly to the platform.

Immediately upon the outbreak of the fire, the truck driver shut off the valve in the filling line and drove his truck out of the yard and into the street, where a few scattered blazes from spattered gasoline were extinguished. In the meantime first aid equipment was brought to the scene of the fire, but



*Baltimore News.*

**Twelve tanks containing about 200,000 gallons of petroleum products, a warehouse building, three tank trucks and three tank cars were destroyed by this fire in Baltimore, which occurred when a fire originated at a gasoline tank truck which was being filled. A gravity connection from the bottom of a storage tank contributed to its spread.**

owing to lack of training in its use the fire gained such headway that the entire plant was involved, with a loss of $67,000. (H-22362.)

SEPTEMBER 14, 1925. MT. VERNON, OHIO. A three-compartment tank truck was at the loading platform of a bulk storage plant and an employee was filling the middle compartment, when there was a flash, and the rear of the truck burst into flames. The employee tried to drive the truck from the building, but could not start the motor. The gasoline in the truck fed the flames, and the loading platform and a small tank of gasoline near by were soon involved. The fire spread to other tanks, with the result that the entire plant was destroyed.

Three fire fighters were showered with blazing gasoline and fatally burned when a hose stream was directed on the hot gasoline tanks. The cause of the fire was thought to have been the ignition of gasoline vapor by a spark from an electrically driven pump. The loss on the tank truck was $1500 and on the plant about $18,000. (H-22445.)

AUGUST 7, 1926. MORRIS, ILL. A tank truck was being loaded with gasoline when, without warning, it burst into flame. The driver was not smoking,

the motor was not running and the truck was apparently properly grounded. The only possible cause of the fire, therefore, seems to be static electricity generated during the filling operation. The driver died from his burns before he could give a coherent account of the accident.

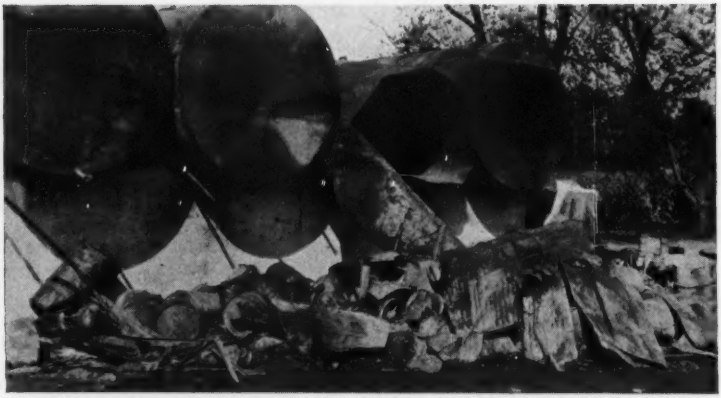
In addition to the tank truck, the fire destroyed an oil warehouse, three storage tanks and a considerable amount of gasoline, kerosene, oil and grease. The loss was estimated at $6200 to the building and tanks, $1800 to the tank truck and $4500 to stock on hand. Four hose streams were used by the fire department to extinguish the fire. (H-23721.)

AUGUST 10, 1926. BALTIMORE, MD. A fire, originating in a gasoline tank truck which was being filled, destroyed the truck, and before it could be brought under control, gutted a large bulk distributing station. The driver of the truck was severely burned and died two days later at a hospital. The cause of the fire was not definitely determined, fire department records stating that it was due to back-fire of the truck's engine, while from other sources it was reported to have been due to static electricity. The tank truck was being filled through a gravity connection from the bottom of a storage tank, and no doubt this arrangement allowed the burning gasoline to spread very rapidly throughout the area. The fire involved twelve tanks containing approximately 200,000 gallons of flammable liquids, a warehouse building and contents, three trucks and three tank cars. The loss was large. (H-23647.)

AUGUST 1, 1927. ST. LOUIS COUNTY, MO. A flash fire occurred while a tank truck was being filled from a storage tank in a gasoline distributing station. The tank truck, which contained 1500 gallons of gasoline, was badly damaged, but the storage tank did not ignite. The fire spread to a two-story brick building on the premises, used as a garage and for the storage of oil. An adjoining dwelling was also badly damaged. The cause of the fire was not determined. (H-24868.)

SEPTEMBER 3, 1927. ELKHORN, WIS. A tank truck, one compartment of which contained about 400 gallons of gasoline, was backed up to a storage tank in the loading building of a distributing station to take on 100 gallons of kerosene in another compartment. The driver was on top of the truck engaged in this operation, when he observed flames in the cab of the truck. He immediately closed the control valve of the fill pipe, jumped to the ground, and opened the door of the cab, where he found flames coming through the floor boards. His first thought was to get the truck out of the building, and he accordingly threw on the switch and pressed the starter, but got no response from the motor. He then made his escape.

The fire spread from the tank truck to grease and oil stored on the near-by loading platform and soon involved the entire plant. The loss to the plant and stock was estimated at $25,000. (H-24912.)



**Defective electrical equipment was responsible for a fire at this Elkhorn, Wis., distributing station that originated beneath the floor boards of a gasoline tank truck which was being loaded. The driver attempted to move the truck from the building, but could not start it. The fire spread to grease and oil stored on the loading platform and soon involved the entire plant. Note ruins of tank truck in foreground.**

JUNE 8, 1928. LOUISVILLE, KY. A gasoline tank truck was backed up to the loading platform of a distributing station and the motor stopped. The caps of the tank compartments were removed and one of the compartments was being filled when the engine backfired (presumably due to racing the motor when shutting it off, thus permitting raw gasoline to enter the hot muffler where it could vaporize and explode) and the gasoline ignited.

The truck was quickly a mass of flames, which communicated to other trucks and to the loading platform. Burning gasoline flowed along the ground between the large storage tanks, but was extinguished by firemen without communicating to the tanks. The loading platform, several trucks and considerable equipment were destroyed, with a loss estimated at $6000 to the trucks and $17,335 to the buildings and equipment. (H-26185.)

JULY 31, 1928. PORTSMOUTH, N. H. A road oil tank truck was being filled from a tank car, when an explosion occurred. The driver of the truck was thrown to the ground by the explosion and suffered burns about the face and hands. His helper, uninjured, closed the discharge valve, thus checking the flow of oil from the tank car. Six hundred gallons of oil were destroyed and the tank truck was damaged beyond repair. In the opinion of the fire chief the explosion was due to excessive heat from the heater attached to the distributing apparatus at the rear of the truck. (H-26291.)

JUNE 1, 1929. BUFFALO, N. Y. A fire occurred at open loading racks in the yard of a gasoline distributing station while tank truck were being filled. It is thought that the ground wire between the supply tank and the trucks was accidentally disconnected and ignition resulted from a static spark. Em-

ployees, using foam extinguishers, had the fire out when firemen arrived. The total loss was $1791, of which $1696 was to two tank trucks and $95 was to loading equipment. (H-32392.)

JUNE 7, 1929. DETROIT, MICH. A tank truck was being filled at the loading rack of a distributing station. Two compartments had already been filled and as the third compartment was about half filled, a sudden flash occurred and the entire truck and loading platform were soon a mass of flames. The ignition of the gasoline vapor may have been caused by static or a spark caused by the striking of the nozzle against the side of the tank. Efficient use of foam and water streams by the fire department confined the damage to the destruction of the tank truck, slight damage to the loading platform, and scorching of two other tank trucks. (H-35175.)

MAY 15, 1930. BALTIMORE, MD. A tank truck was being loaded with gasoline at the loading shed of an oil compounding, blending and distributing plant, when a flash fire occurred. The cause of the fire may have been a static spark or a short circuit in the wiring of the truck. Employees turned in an alarm and directed the contents of a 2½-gallon foam extinguisher into the truck tank. The fire was temporarily brought under control, but the tank was so full that the addition of the foam caused it to overflow, re-ignite and spread the fire. Foam streams were then brought into play and the fire was held in check until the arrival of the fire department.

The fire might have been controlled at this point with nominal loss had it not been for the rupture of a two-inch feed pipe from a 45,000-gallon gasoline storage tank. This added fuel to the flames, which were not extinguished until a considerable quantity of gasoline had been destroyed. The loss was confined to the loading shed, tank truck and about 15,000 gallons of gasoline. Minor damage was done to several adjacent tanks and small structures. (H-29791.)

AUGUST 1, 1931. ROWLESBURG, W. VA. This fire occurred in a small gasoline and oil distributing station, where gasoline and oil were stored in three above-ground tanks. At the time of the fire a tank truck was backed up to a loading platform in the center of the property to be filled with gasoline. The driver set the emergency brakes and left the truck. For some reason the brakes did not hold and the truck backed off the loading platform, which sloped toward one of the gasoline tanks. The rear bumper of the truck struck the discharge valve on this tank, breaking it off at the union, and thus permitting the gasoline to escape. The driver of the truck, showing unusual presence of mind and courage, drove a wooden plug into the pipe, stopping the flow of gasoline.

A rubbish fire, however, was burning about one hundred and fifty feet away and the gasoline which had already escaped flowed to this fire, where it ignited and flashed back, the burning gasoline on the ground soon increasing

the pressure in the tank, so that the wooden plug was blown out. The escaping gasoline burned until the entire contents of the tank were consumed.

The safety vents at the top of the two gasoline tanks operated, the escaping vapors igniting and burning with an intense flame. The tanks themselves, of standard steel construction, suffered comparatively little damage other than bulging. Only a fraction of the gasoline in the second tank was consumed. A tank containing kerosene was not ignited.

The fire spread to the lumber piles of an adjoining lumber yard and destroyed about 150,000 feet of lumber. The total loss was estimated at $50,000. The tank truck was destroyed. (H-33781.)

SEPTEMBER 7, 1932. BUFFALO, N. Y. A tank truck having four 250-gallon compartments had just been loaded with gasoline at a bulk distributing station. The fire occurred when the driver, who had the filling hose in one hand, pushed the stop button for the gasoline pump motor and simultaneously shut the quick-closing valve on the gasoline pipe. The cover was still off of the last compartment to be filled and vapor above this compartment ignited. At the time of the fire the tank truck was half inside the filling building and fire spread to the joisted roof. Five men extinguished the building fire with two hose streams and the gasoline fire by use of a foam generator and two cans of powder. The loss was approximately $2500. (H-36614.)

DECEMBER 16, 1932. DENVER, COLO. A fire occurred in a gasoline and oil bulk station when a truck being used to tow a disabled truck from the plant garage backed into the discharge connection of an above-ground gasoline tank, breaking it off. The escaping gasoline sprayed the rear of the truck and it is thought that ignition resulted from the contact of the gasoline with the hot exhaust pipe of the truck.

The fire not only destroyed the tank truck, but spread to several storage tanks and other adjacent property. The burning gasoline flowed into a storm sewer, where several explosions caused serious damage. The loss to the tank truck was about $3000, while the damage to other property, including the sewer, was estimated in the vicinity of $30,000. (H-36171.)

JANUARY 4, 1933. SHREVEPORT, LA. A tank truck was being filled at a refinery when a flash fire occurred. It is thought that a static spark igniting gasoline was responsible. The tank truck was destroyed and the loading rack and several near-by tanks were damaged. The total loss, including buildings, tanks, tank truck and stock, was $8291. (H-36551.)

## Fires Occurring in Connection with Unloading Operations.

The number of fires which have occurred in tank trucks and/or trailers in connection with unloading operations is twenty-three. Five of these involved only the tank truck, twelve involved the tank truck and the filling station or garage where unloading operations were being carried out, and six spread

to other property. All of the tank trucks and/or trailers involved in the fires were transporting gasoline.

Thirteen fires were responsible for the loss of twenty-six lives and injury to seventy persons. Of those killed, six were employees and twenty were other persons. Twenty employees suffered injury and also fifty other persons. Two fires were responsible for the greater part of the loss of life and injuries. The Downey, California, disaster of April 12, 1922 (QUARTERLY, January, 1925, Vol. 18, No. 3, p. 287), accounted for nine deaths and forty-one injuries, and the Pittsburgh explosion of August 29, 1924 (QUARTERLY, January, 1925, Vol. 18, No. 3, p. 290) took a toll of eleven lives, four of which were children, and injured seven other persons.

The following table indicates the causes of fires which have occurred in connection with unloading operations. An analysis of the original reports making up this table indicates that the improper location of the filling connection to underground tanks was a contributing factor in the origin of the fire.

### Causes of Fires—Unloading Operations.

| Cause | No. Fires |
|---|---|
| Gasoline fumes ignited during unloading operation | 14 |
| Ignition from lighted match | 3 |
| Ignition from motor exhaust | 2 |
| Ignition from hot motor | 1 |
| Ignition from motor of adjacent motorcycle | 1 |
| Ignition from electric heater in filling station office | 1 |
| Ignition from electric pump switch | 1 |
| Ignition from firecracker | 1 |
| Ignition from undetermined cause | 4 |
| Static electricity in discharge hose | 4 |
| Discharge valve left open — gasoline flowed to heater in basement | 1 |
| Total known causes | 19 |
| Cause unknown | 4 |
| Total fires | 23 |

### Analysis of Loss—Unloading Operations.

| Loss | All Fires | | Tank Truck Only | | Tank Truck and Other Property | |
|---|---|---|---|---|---|---|
| | No. | Loss | No. | Loss | No. | Loss |
| Small | 3 | ..... | 3 | ..... | .. | ..... |
| Less than $10,000 | 1 | $1,000 | 1 | $1,000 | .. | ..... |
| $10,001 to $50,000 | 5 | 176,000 | .. | ..... | 5 | $176,000 |
| Over $50,000 | 3 | 435,000 | .. | ..... | 3 | 435,000 |
| Large (no figures) | 7 | ..... | .. | ..... | 7 | ..... |
| Considerable | 2 | ..... | 1 | ..... | 1 | ..... |
| No data as to amount of loss | 2 | ..... | 2 | ..... | .. | ..... |
| Total | 23 | | 7 | | 16 | |

**Wreckage of gasoline tank truck involved in the Downey, Cal., explosion of April 21, 1922. Nine dead, forty-one injured.**

## Typical Fires in Connection with Unloading Operations.

SEPTEMBER 29, 1927. CHICAGO, ILL. A fire started while an underground gasoline tank was being filled from a tank truck. The cause of the fire, while not definitely determined, was possibly a static spark, as the ground chain of the truck was not in contact with the ground. Gasoline, which had been spilled, ignited and the fire was fed by additional gasoline escaping from a faucet on the tank truck, which had been left open. An important factor in the control of the fire was the work of a fire department officer, who under the cover of a hose stream closed the faucet. Considerable damage was done to the filling station and adjoining garage. (H-25039.)

JANUARY 12, 1929. MILWAUKEE, WIS. Four underground gasoline tanks in the basement of a garage were being filled from a tank truck through outside connections. Due to a short hose on the tank truck, two wheels of the truck were backed on to the sidewalk. The truck slid off the curb and broke the valve on the tank connection. About 200 gallons of gasoline flowed into the street and was ignited by a match or cigarette butt thrown by a passer by. Firemen promptly extinguished the fire. Minor damage was done to the outside of the garage. (H-32517.)

JANUARY 8, 1930. CRESCO, IOWA. A gasoline tank truck backed into the rear wall of a garage and filling station and knocked off a faucet from the tank. Gasoline spread over the floor of the garage and flowed outside where

it was ignited from an unknown cause. Fire flashed back into the building. Two lives were lost when a man attempted to rescue an invalid woman living above the garage. Both were trapped. The building and contents were destroyed with a loss of $48,400. (H-29138.)

DECEMBER 29, 1930. VISALIA, CALIF. A fire occurred at a gasoline distributing station where a tank truck and trailer were about to be unloaded. When the cap to the discharge pipe on the truck was removed a stream of gasoline shot out, flooding the area in the vicinity of the truck and trailer and the combination pump house and office building. An electric heater in the office was operating and gasoline fumes ignited therefrom and flashed back. The driver and four employees of the station were caught by the fire and suffered burns. The most seriously injured was the driver of the tank truck, who was under the truck struggling with the valve when the fire started.

Shortly after the start of the fire (estimated at 8 to 10 minutes) the dome cover of the trailer, which was about three feet in diameter, let go, shearing the bolts and going straight up into the air and landing in an alley alongside the plant. During the course of the fire the rear compartment of another truck in the yard exploded violently. Two other trucks in the yard were also involved in the fire. All trucks and the trailer were a total loss, as was also the building of the station. (H-35278.)

FEBRUARY 20, 1931. NEW ORLEANS, LA. A fire occurred while an underground storage tank inside a garage was being filled from a gasoline tank truck outside of the building. The filling hose extended from the truck to the fill pipe which was just inside the door. One compartment of the truck had been emptied and the second was about half empty when fire broke out at the fill line of the underground tank. The driver, becoming excited, attempted to drive the truck away from the building, but failed to detach the hose. The hose consequently broke and allowed the contents of the compartment of the tank truck to flow onto the floor of the garage and add to the fire. The fire was probably caused by a static spark between the fill pipe of the underground tank and the non-standard gasoline nozzle. The truck was not equipped with a static chain or remote control valves. The garage was entirely destroyed. (H-33310.)

JUNE 11, 1931. EDMONTON, ALTA. The tank truck which was directly responsible for this fire had been constructed locally. It was a six-wheeled affair, consisting of two tanks on a wooden timber frame, the forward end of which was supported on the rear of a small automobile truck and the rear on a trailing axle. A ground chain was attached to the chassis of the truck, but with the wooden timber frame there was no electrical connection with the tanks and the chain was of no value. It is obvious that little or no thought for fire safety was given in the construction of the truck.

**This home-made tank truck, with tanks mounted on a wooden frame with no ground connection, was responsible for a fire that destroyed a garage in Edmonton on June 11, 1931. A grounding chain had been provided, but this was attached to the automobile chassis and not connected to the tanks.**

The fire occurred on a hot day. The truck had transported a load of gasoline to Calgary prior to coming to Edmonton, at which time there were 1141 gallons in the two tanks. The truck was driven into the garage to deliver gasoline to the underground tank, the fill pipe of which was located inside the building instead of in a proper location outside.

Having lost his tank hose on the trip, the driver attempted to use a metal-lined rubber-covered hose which he took from a gasoline pump in the garage. The nozzle on the hose was too large to go into the fill-pipe opening, so a funnel was placed therein and the gasoline allowed to run into the funnel. About 300 gallons of gasoline had been emptied into the tank when an explosion occurred, followed by a fire which spread rapidly through the one-story brick building.

Static electricity is given as the cause of the fire. With the makeshift hose and funnel, there was every opportunity for ignition of gasoline vapor by a static spark. Static electricity may have accumulated in the tank during the long trip due to the lack of any grounding facilities, or have been generated during the flow of gasoline through the hose and funnel, which may not have been in proper metallic contact. Whatever the immediate cause of ignition, the non-grounded sub-standard tank truck, the makeshift tank-filling arrangement and the conduct of the tank-filling operation in the building were clearly responsible, any one of the three factors along being sufficient to account for the fire. (H-32917.)

SEPTEMBER 9, 1932. MIAMI, ARIZ. Gasoline was being pumped from a large transport truck into an elevated storage tank at a marketing station. The trailer of the truck had been emptied and detached and the remainder of

the 6000-gallon cargo was being unloaded from the tank truck. Either from carelessness or lack of close observation, the storage tank was allowed to overflow, and approximately 300 gallons of gasoline were spilled. When this condition was noted, a plant employee rushed to the pump house and it seems apparent that he threw the switch to stop the pump, causing a spark which ignited the vapor from the escaped gasoline. A rush of flame, accompanied by a violent explosion, instantly occurred. The buildings at the station collapsed due to the force of the blast.

The agent was instantly killed, his charred body being found in the ruins adjacent to the pump house. Another attendant who had attempted to run away was burned to death before he could get through the gate. The driver of the tank truck was severely burned, but escaped after closing the emergency valve on the truck. The fire burned furiously, accompanied by slight detonations. There were no further violent explosions.

Besides the transport truck there were three other tank trucks, of the compartment type, destroyed in the fire. None of these trucks were equipped with venting facilities, except that each compartment dome had a 3/16-inch hole drilled through its center. Two of these trucks were parked in the garage building. In these there was no rupture of tanks, and although they ballooned, they did not open at the seams. The third truck, of somewhat larger capacity, was standing near the filling shed and three of the compartments of this truck burst.

The fire was fought by the local fire department, using only water, and was brought under control in eight hours. No explosions occurred in any of the elevated storage tanks, as internal pressure was relieved through explosion hatches. These tanks burned until they were empty. The total damage was estimated at $50,000. (H-36168.)

# Halifax, N. S., Pier Fire.

Early on the morning of September 19, 1933, the upper level of Pier No. 2 of the Halifax, Nova Scotia, Harbor Commission was swept by a fire with a resultant loss of more than half a million dollars. The fire seriously damaged the reinforced concrete pier structure, the destruction of the upper floor and of the contents stored therein being practically complete. Large areas, without firestopping, filled with combustible material, and the absence of automatic sprinkler protection were factors in the large loss.

## Description of the Pier.

The property involved in the fire was a reinforced concrete pier 680 feet long by 200 feet wide, having a total area of 136,000 square feet. The substructure consisted of reinforced concrete piling with deck slabs of 9-inch reinforced concrete. The pier structure consisted of a 2-story warehouse having walls of reinforced concrete and 6-inch tile, upper floor of 7-inch reinforced concrete, and a roof consisting of a 3½-inch concrete slab covered with 5-ply felt and tar laid on 2 x 3-inch furring and 1-inch wood sheathing.

The walls of the warehouse were lined with 2 x 4-inch furring and eel grass with ½-inch insulating sheathing. The second floor had a 1½-inch plank floor on 2 x 3-inch sleepers lined with eel grass for insulation, and the ceiling was similarly lined and sheathed with eel grass, 2 x 3-inch furring and ⅜-inch sheathing. The upper floor and roof were supported by 25-inch reinforced concrete columns, 12 x 27-inch concrete beams and 36 x 50-inch concrete girders.

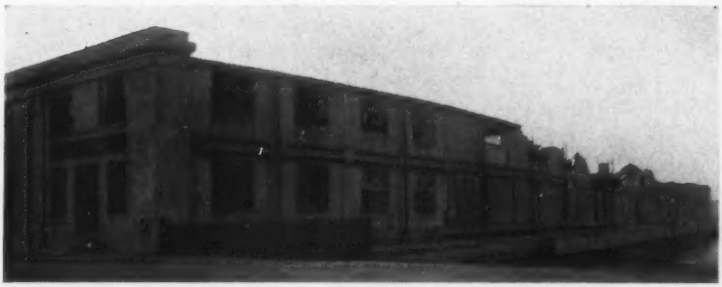
There were seventeen enclosed concrete stairways and escalators protected by steel doors between the first and second floors. There were no fire walls. The upper shed where the fire occurred was divided into three equal sections by partitions of wood and insulating sheathing. Electric wiring was in exposed conduit. Heating was by hot water from a central plant outside the building.

The lower floor of the pier was used for transit freight, with flour and feed cribs in the outer seven bays. Customs, railway and steamship offices were at the land end of the first floor. The upper floor was used as a warehouse for flour and other cereals, canned goods, etc., with a warehouse office at the land end.

## Fire Protection.

Private fire protection consisted of ten standpipes, each with 50 feet of 2½-inch hose and nozzle on upper floor, twelve 2½-gallon soda-acid extin-

This report has been prepared largely from data furnished by Major J. A. Rudland (Member N.F.P.A.), Fire Marshal of Nova Scotia, supplemented by information from other sources.



*Allen Fraser.*

**South side of Halifax, N. S., pier after the fire. The fire had its origin on this side of the pier at the center and extended east and west throughout the entire upper floor. Note fire alarm box on front of structure at extreme left of picture, which watchman failed to see, but proceeded to another box 800 feet distant.**

guishers and two 20-gallon soda-acid chemical engines. Watch service was provided by the uniformed police of the Halifax Harbor Commission. No clock system was provided.

City fire protection available consisted of five motor pumpers, a hose car and two ladder trucks manned by a force of 94 officers and men operating under two platoons and commanded by Chief J. W. Churchill. All of this equipment was called to the fire, two of the pumpers being later relieved by reserve steam fire engines.

### Events Preceding the Fire.

At the time of the fire there were about 4000 tons of cereals on the second floor of the pier. The S.S. *Moyra* was lying at the north side of Pier No. 2, and up to 11 P.M. (approximately three hours prior to the fire) this vessel had been discharging a cargo of flour. The cargo was received in slings on the overhanging platforms on the upper level of the pier and transferred by hand trucks to piling space in the southeast corner of the center compartment. Warehousemen and foremen were in charge of the work and from time to time policemen passed through on inspection duties. Upon completion of the unloading at 11 P.M. the stevedores left the building, inspection was made of the structure, lights were turned off and the steel doors between the floors were secured. No sign of fire was seen. There was a relief of police duties at 11:55 P.M.

### Story of the Fire.

At about 1:30 A.M. the policeman who had come on duty at midnight started on his first inspection of the second floor. He was proceeding up the stairway at the northwest corner of the building, when he became aware of an unusual odor, not, however, like smoke, and at the same time he noted that the atmosphere was hazy. He was about to open a door leading into the second floor when the transom was blown outward and fell upon him. He was

momentarily dazed, but soon recovered and realized that the building was on fire. By this time smoke was coming from the opening above the door and he ran from the building to give an alarm. In his confusion he forgot the fire alarm box located at the land end of the building and ran to the box at Pier No. 4, 800 feet away. The alarm was received by the fire department from this box at 1:43 A.M.

When the watchman returned to Pier No. 2 flames were coming from the upper part of the building, breaking through the windows above the cargo doors at about the center of the south side of the structure. This was the area in which the cargo unloaded from the S.S. *Moyra* a few hours previous had been stored. Flames were also coming from ventilators and other openings, and it was obvious when the fire department arrived that a fire of considerable proportions was in progress. At the extreme west or land end of the building was a large fan type ventilator which commenced to revolve at great speed, making a noise like a large siren. The motor was not operating and the revolutions were no doubt caused by the rush of air and gases from the building.

The first alarm was answered by two pumpers, a hose car, a ladder truck and the two chief officers of the department. A second alarm at 2:06 A.M. and a third at 2:36 A.M. summoned the rest of the equipment and both platoons of firemen. Upon the arrival of the first alarm apparatus, attempts were made to run hose lines into the second floor, but heavy smoke, gases and heat prevented their operation. In the hope that ventilation might improve this condition, hatches at the west end of the roof were opened, but while this tended to draw the flames through these openings it did not make access to the seat of the fire possible.

Lines of hose were then run through the lower floor and from standpipes on that floor, and streams were directed through escalator openings and from the head of two concrete stairways at the west end of the structure. At one escalator (the first to be opened) the firemen found themselves directly beneath the fire. They attacked the fire vigorously at this point for a considerable period, although forced to temporarily vacate their position from time to time by smoke and flames. Five lines in all were operated through floor openings.

Six lines of hose were run along the outside of the building and streams were directed from ladders on the south side. Two streams were similarly operated on the north side. From time to time these points of attack had to be changed, for the tops of the ladders were constantly endangered by the flames. The streams from outside were not very effective, due to long lines and consequent reduced pressures, and also due to the fact that the firemen had to direct the streams with their heads below the level of the window sills (due to flame which broke through the windows) and could not see where the

*Allen Fraser.*

**Ruins of upper floor of Pier No. 2, Halifax, N. S., showing complete destruction of contents and collapsed roof. This fire illustrates the importance of fire walls and automatic sprinkler protection for large area buildings housing combustible contents even though the structures are fire-resistive.**

water fell. The firemen, however, maintained these positions until the walls began to crumble, when they were abandoned for safer locations.

The positions within the building were maintained by the firemen as far as the two concrete stairways located at about the center of the west section of the pier, and the fire department concentrated its hose streams at this point. By this time the fire had practically destroyed the upper part of the pier, but the débris was still burning with great intensity. The fire continued to burn with some intensity until the third day, and ten days later was still smouldering.

### Effect of Fire Upon the Structure.

The partial destruction of this reinforced concrete structure of modern design is a clear-cut illustration of the limitations of fire-resistive construction. While this pier was of a relatively superior type of construction as compared with other piers which have been involved in recent fires and was popularly regarded as "fireproof," it fell far short of the standards recommended by the N.F.P.A. Committee on Piers and Wharves. This committee in the "Recommended Good Practice for the Construction and Protection of Piers and Wharves" calls for division of pier sheds by fire walls in order to reduce the area subject to a single fire. According to the committee's recom-

mendations, there should have been at least two standard fire walls across this pier. The two partitions apparently had no effect in retarding the spread of fire. Standard fire wall construction might have been substituted for these partitions at no very great increase in expense.

There was no automatic sprinkler protection provided. Owing to the large areas and inaccessibility of fires in closely piled cargo, it is often exceedingly difficult for fire departments to do effective work on pier fires. For this reason the N.F.P.A. committee has specified automatic sprinkler protection for all pier structures, irrespective of whether built of reinforced concrete or combustible materials. This fire amply justifies this recommendation of the committee.

The wooden flooring, ceiling and insulating material added a great deal of fuel, and the spread of fire beneath the flooring and behind the ceiling was presumably an important factor.

With 4000 tons of cereals and combustible flooring, ceiling and insulating material, there was an average of at least 75 lbs. of combustible material per square foot of floor area on the second story. There is no information as to how much additional combustible material may have been furnished by the packings of other cargo, such as canned goods. Seventy-five pounds of combustible material per square foot of floor area is more than sufficient to produce a fire of the intensity and duration of an 8-hour fire test on the standard time temperature curve. The areas of the building were so great and the difficulty of access such that it appears probable that fire department hose streams were not effective except to a limited extent near their point of application and there were large portions of the area not reached by water.

There is no information to indicate any deviation from the best standards of fire-resistive concrete construction in respect to the quality of the concrete used or the distance of reinforcing bars from the surface of the concrete. The effects of the fire, resulting in complete collapse of large portions of the concrete structure, may be explained without assuming any deficiency in quality of the concrete construction. A $3\frac{1}{2}$-inch reinforced concrete roof slab such as was used in this building has a rating of $1\frac{1}{2}$ hours on the standard time temperature curve, according to test data. The exposure of concrete having a $1\frac{1}{2}$-hour rating to an 8-hour fire would naturally result in failure. The failure of the heavier concrete columns and girders may be explained as the result of unequal heat expansion.

Despite the partial failure of the structure, this fire should not be construed as any reflection upon the value of reinforced concrete. The concrete construction should be credited with limiting the damage to the second floor of the building, and made it possible for the fire department to fight the fire at close range. The fire forcefully illustrates the importance of compliance with the recommendations of the N.F.P.A. Committee on Piers and Wharves

for subdivision of large areas by fire walls and automatic sprinkler protection for all pier sheds irrespective of their construction.

### Cause and Loss.

While it was not possible to definitely determine the exact cause of this fire, the most probable cause, on the basis of available evidence, appears to be carelessness in the disposal of smokers' materials. The total loss is estimated at $402,000, of which $250,000 is on the building valued at $752,000; $15,000 is on the machinery, a total loss; and $137,000 is on the contents, valued at about $300,000. No insurance was carried on the structure, but the contents were covered.

# Fires in Which There Was Loss of Life.

## Fourth Quarter, 1933.

Since the publication of the October QUARTERLY, the N.F.P.A. Department of Fire Record has received from various sources 128 reports of fires in which there has been loss of life. A total of 262 lives were lost in the fires included in this tabulation.

## Loss of Life Fires, October-December, 1933.*

*This is a typical rather than a complete record, presented to show the conditions under which loss of life occurs, that they may be known and guarded against. The total loss of life by fire in the United States is estimated at 10,000 annually.*

| Class of Fire | No. Fires | Men | Women | Children | Total |
|---|---|---|---|---|---|
| Airplane fires | 6 | 17 | 2 | 0 | 19 |
| Apartments, hotels, lodgings, tenements, etc. | 15 | 9 | 11 | 6 | 26 |
| Automobile fires | 3 | 7 | 3 | 0 | 10 |
| Barns and stables | 1 | 0 | 0 | 2 | 2 |
| Dwellings—Rural | 31 | 8 | 15 | 38 | 61 |
| Dwellings—Urban | 31 | 13 | 22 | 17 | 52 |
| Fireworks factory | 1 | 1 | 0 | 0 | 1 |
| Forest or brush fires | 2 | 29 | 0 | 0 | 29 |
| Industrial occupancies | 5 | 4 | 1 | 0 | 5 |
| Institutions, schools, etc. | 1 | 1 | 0 | 0 | 1 |
| Mercantile occupancies | 3 | 3 | 0 | 0 | 3 |
| Oil refineries and distributing plants | 3 | 6 | 0 | 0 | 6 |
| Other buildings | 13 | 17 | 3 | 10 | 30 |
| Outside of buildings | 8 | 0 | 0 | 8 | 8 |
| Response to alarms | 3 | 3 | 1 | 1 | 5 |
| Ships and boats | 1 | 3 | 0 | 0 | 3 |
| Tank ships or barges | 1 | 1 | 0 | 0 | 1 |
| Total | 128 | 122 | 58 | 82 | 262 |

*This table is made up from those reports received by the Department of Fire Record between October 1 and December 31, 1933. A few of the fires included herein occurred prior to October 1, but were not reported until subsequent to that date.

# Causes of Loss of Life, October-December, 1933.

*Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.*

| Causes | Men | Women | Children | Total |
|---|---|---|---|---|
| Airplane fires | 19 | 2 | 0 | 21 |
| Airplane crashed on house | 1 | 2 | 2 | 5 |
| Automobile fires | 7 | 3 | 0 | 10 |
| Children alone in house | 0 | 0 | 13 | 13 |
| Children and matches | 0 | 0 | 4 | 4 |
| Cleaning with gasoline | 1 | 3 | 0 | 4 |
| Clothing ignited: | | | | |
| Bonfire, rubbish, etc. | 0 | 1 | 6 | 7 |
| Electric heater | 0 | 1 | 0 | 1 |
| Furnaces or stoves | 0 | 9 | 0 | 9 |
| Hot brick placed in bed | 0 | 1 | 0 | 1 |
| Oil stoves or lamps | 1 | 2 | 0 | 3 |
| Escaping from fire—drowned | 3 | 0 | 0 | 3 |
| Explosion: | | | | |
| Alcohol tank | 1 | 0 | 0 | 1 |
| Dust | 0 | 1 | 0 | 1 |
| Fireworks factory | 1 | 0 | 0 | 1 |
| Gasoline barge | 1 | 0 | 0 | 1 |
| Gasoline stove | 0 | 0 | 2 | 2 |
| Gasoline tank | 2 | 0 | 0 | 2 |
| Lacquer drum used for range oil | 1 | 0 | 0 | 1 |
| Natural gas | 1 | 0 | 0 | 1 |
| Natural gas plant | 3 | 0 | 0 | 3 |
| Oil refinery | 5 | 0 | 0 | 5 |
| Oil stove or lamp | 1 | 1 | 2 | 4 |
| Unknown | 2 | 1 | 0 | 2 |
| Fire fighting | 6 | 0 | 0 | 6 |
| Fireworks | 1 | 0 | 0 | 1 |
| Forest or brush fire fighting | 29 | 0 | 0 | 29 |
| Gasoline used to start fire | 2 | 1 | 0 | 3 |
| Ignition of flammable liquids or vapors | 2 | 2 | 2 | 6 |
| Kerosene used to start fire | 2 | 3 | 8 | 13 |
| Motion picture film ignited | 2 | 1 | 9 | 12 |
| Overcome by smoke—suffocation | 2 | 2 | 1 | 5 |
| Re-entering burning buildings to save life or property | 4 | 1 | 2 | 7 |
| Response to alarms | 3 | 1 | 1 | 5 |
| Smoking | 3 | 2 | 0 | 5 |
| Trapped in burning buildings | 16 | 18 | 30 | 64 |
| Total | 122 | 58 | 82 | 262 |

Seven disasters in which more than five lives were lost occurred during the period covered by this record, as follows:

October 3, 1933. Los Angeles, Calif. Twenty-eight unemployed relief workers were trapped while fighting a forest fire in a canyon at Griffith Park Playground and were burned to death. (A report of this fire is published on page 194 of this issue of the QUARTERLY).

October 9, 1933. Pequot, Minn. A woman and her six children, ranging in age from seven months to nine years, were burned to death when fire destroyed their home. The father was at work at the time.

October 10, 1933. Chesterton, Ind. Seven persons, including two women, lost their lives when an air liner caught fire in the air from an undetermined cause and crashed in flames.

November 3, 1933. New York, N. Y. Nine persons, six of them children, were burned to death when fire swept through an old frame tenement in Brooklyn, occupied by negroes. Three other occupants were severely burned. The building was a mass of flames when firemen arrived.

November 5, 1933. Shrewsbury, N. J. Seven persons were killed when an airplane crashed into a house near an airport, setting the house on fire. Two of the victims were occupants of the airplane and five were occupants of the house, who were trapped by flames before they could escape.

November 12, 1933. Caguas, Puerto Rico. Nine children and two adults were fatally burned when motion picture film ignited in a little shack in which an amateur motion picture show was being given. Fire started when exposed nitrocellulose motion picture film ignited from a candle.

December 8, 1933. Sault Ste. Marie, Mich. Seven persons were burned to death in a fire which started from an overheated stove while they were asleep. The victims included two women and five children.

## Typical Loss of Life Fires.

### Cleaning with Gasoline.

L-2248. DANVILLE, VA., NOVEMBER 18, 1933. Two women were fatally burned when sprayed with blazing gasoline which they were using to clean a dress in the kitchen of their home. Fumes from gasoline in an open crock ignited from the kitchen stove. The victims, a mother and daughter, were alone in the house.

L-2243. MONTREAL, P. Q., DECEMBER 3, 1933. Wearing a suit of clothes which he had cleaned with benzine a short time before, a man struck a match on his trousers, intending to light the gas stove. The suit burst into flames and the wearer was fatally burned.

### Gasoline Used to Start Fire.

L-2259. HARRISONBURG, VA., OCTOBER 7, 1933. A man died from burns received when he threw gasoline, mistaken for kerosene, into his furnace. He managed to beat out the flames and staggered up the cellar steps. He was badly burned about the head and body and died the next day. The explosion split the door leading to the cellar.

**Kerosene Used to Start Fire.**

L-2254. LILY, S. D., OCTOBER 26, 1933. A woman was burned to death when her clothing ignited as a result of starting a fire in a cooking stove with kerosene. Her husband was in the yard near the farmhouse when the accident occurred. He rushed in and dashed a pail of milk and a pail of water over his wife, extinguishing the fire, but not before she was fatally burned.

H-37311. EATON RAPIDS, MICH., NOVEMBER 11, 1933. The wife and daughter of the only paid fireman in the town were burned to death in their apartment above the fire station as a result of using kerosene to revive a fire in the kitchen stove. The husband and another man on the floor below heard the explosion which occurred when the kerosene struck the live coals in the stove. They rushed upstairs and saved three children, but the bodies of the mother and her youngest daughter were not recovered until after the fire was extinguished.

**Clothing Ignited from Stove or Furnace.**

L-2245. SKOWHEGAN, ME., NOVEMBER 26, 1933. A woman 79 years old was burned to death while alone in her apartment when her clothing ignited when she attempted to start a fire in her kitchen stove. Bits of charred clothing were found in different rooms, indicating that she first started to go outdoors and then turned back to the living room, where her body was found. Officials believe that she tried to wrap a rug about herself to put out the flames. The body was discovered by a woman living in the apartment above.

**Ignition of Flammable Liquids or Vapors.**

L-2255. ENTERPRISE, W. VA., OCTOBER 25, 1933. A farm employee was killed in an explosion which occurred when he looked into a gasoline tank while carrying a lighted lantern on his arm. The flame of the lantern ignited gasoline vapors and the man was blown a considerable distance and instantly killed by the explosion.

H-37312. BOSTON, MASS., NOVEMBER 11, 1933. A young man was killed by an explosion which occurred when he attempted to install a faucet in a drum in which he planned to store range oil. A label on the drum indicated that it had previously been used for lacquer. An explosive vapor-air mixture in the drum ignited, the head of the drum was completely blown off, and ten windows in the cellar and two doors on the first floor were blown out. The victim was carried from the burning cellar by his mother and taken to the hospital, where he died.

L-2244. NEW YORK, N. Y., DECEMBER 3, 1933. Two men and a woman were fatally burned and two other men were injured in a fire which occurred in an apartment house when paint remover, which was being used on the floors, ignited from an electric spark from a wall socket. The victims were a man and wife in whose apartment the fire occurred and one of the painters, who died of injuries after being carried out by firemen.